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Nutritional status and dietary adequacy in rural communities of a protected area in Gabon

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Abstract

Objective: As part of a larger study designed to understand how to protect the food and nutrition security of individuals living in a protected area of Gabon, we assessed their nutritional status and its relationship to dietary adequacy and health status.

Design: A 7 d food consumption survey was conducted during each of the two major seasons using a weighing method. Data were also collected on weight, height and health of individuals as well as on sociodemographic characteristics and potential determinants of the nutrition situation.

Setting: Four rural communities were intentionally selected to represent both inland and coastal settings and access to food markets.

Subjects: Approximately 500 individuals representing over 90 % of the population of these communities participated in the survey during each season.

Results: Undernutrition was present in the area, particularly among children <5 years of age and the elderly. Health was generally good and under-fives were most frequently ill. Energy, Fe and vitamin A requirements of individuals were generally not satisfied; the opposite was true for protein. The estimated prevalence of inadequate intakes of energy and vitamin A was very high in most age groups. Global nutrient adequacy was associated with nutritional outcome.

Conclusions: Individuals do not eat enough and breast-feeding practices are poor. Many suffer from undernutrition, particularly young children and the elderly. The results confirm the need to investigate the determinants of this poor nutrition situation to ensure that protection of natural resources will not be associated with harm to the well-being of the population.

Keywords
Nutritional status
Dietary adequacy
Gabon
Protected area
Food groups
Breast-feeding

About 300 million persons globally earn part or all of their livelihood from forests, using their resources either directly as food, medicine or fuel, or selling them for income[1]. Protected areas designed to preserve biodiversity have been associated with a loss of access to natural resources for people living in and around them[2].

In Gabon, the Gamba Complex of Protected Areas (the Complex) contains some of the most biologically diverse forests on the African continent. In 1993, it was inhabited by approximately 10 000 persons spread out in thirty-three villages (2973 inhabitants) and one city (7226 inhabitants)[3]. If legislation prohibiting the extraction of natural resources (e.g. wild fruits, bushmeat, fish)[4] were applied consistently, there is serious concern over the possibility of harmonizing the needs of people and the conservation of resources. This is especially the case in rural areas where people rely on natural resources for their livelihood. To design legislation that protects both, it is necessary to understand the relationship between the population and natural resources in the Complex.

In spite of apparent wealth (per capita gross national income $US 4505), life expectancy in Gabon is 54 years[5]. Undernutrition is a concern: national data[6] indicate that 21 % of children <5 years of age are stunted and 7 % of women have BMI < 18·5 kg/m^2. At 10 878 kJ (2600 kcal) per capita per d, food availability is estimated at 1088 kJ (260 kcal) below requirements[7]. No data specific to the population of the Complex are available.

Nutritional status is recognized as an indicator of development and well-being[8]. For children to grow adequately or for adults to have an adequate nutritional status, several conditions must be met. Their food consumption and their health status – which act in synergy – are the immediate determinants of their nutritional status[9]. These, in turn, result from determinants operating at the underlying level of their family and community as well as at the more

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fundamental levels of society. Nutritional status is thus seen as the outcome of processes in society. The present paper describes the nutritional status and dietary adequacy of individuals living in the Complex and examines their relationship as well as that with health status. Future papers will focus on the underlying determinants of the nutrition situation and on their relationship to the use of natural resources.

Methods

Population and sample

Over 80 % of the rural population of the Complex lived in twenty-four villages[10–12]: fifteen were inhabited mainly by the Balumbu (799 inhabitants) and nine by the Bapunu (1065). Moreover, two-thirds lived either in the coastal area (656) or on the continent (1091). The former was inhabited mainly by the Balumbu and the latter by the Bapunu. Each village had more or less easy access to a public food market based on distance (≤40 km or more) or time travelled (≤20 min or more).

Sampling intended to represent the two locations, 'coastal' or 'continental', and ease of access to food markets. Villages were non-randomly selected. Each village was assigned to one of four strata as follows: (i) coastal, poor access to food market; (ii) coastal, easy access; (iii) continental, poor access; or (iv) continental, easy access. Within each stratum, the most densely populated village was selected: Sette Cama (first stratum), Ibouka (second), Doussala (third) and Mourindi (fourth stratum; Fig. 1). They represented approximately 30 % of the rural population of the Complex.

The principal investigator (main author) had spent the prior years doing participatory rural appraisals in the Complex which facilitated data collection. During a visit,

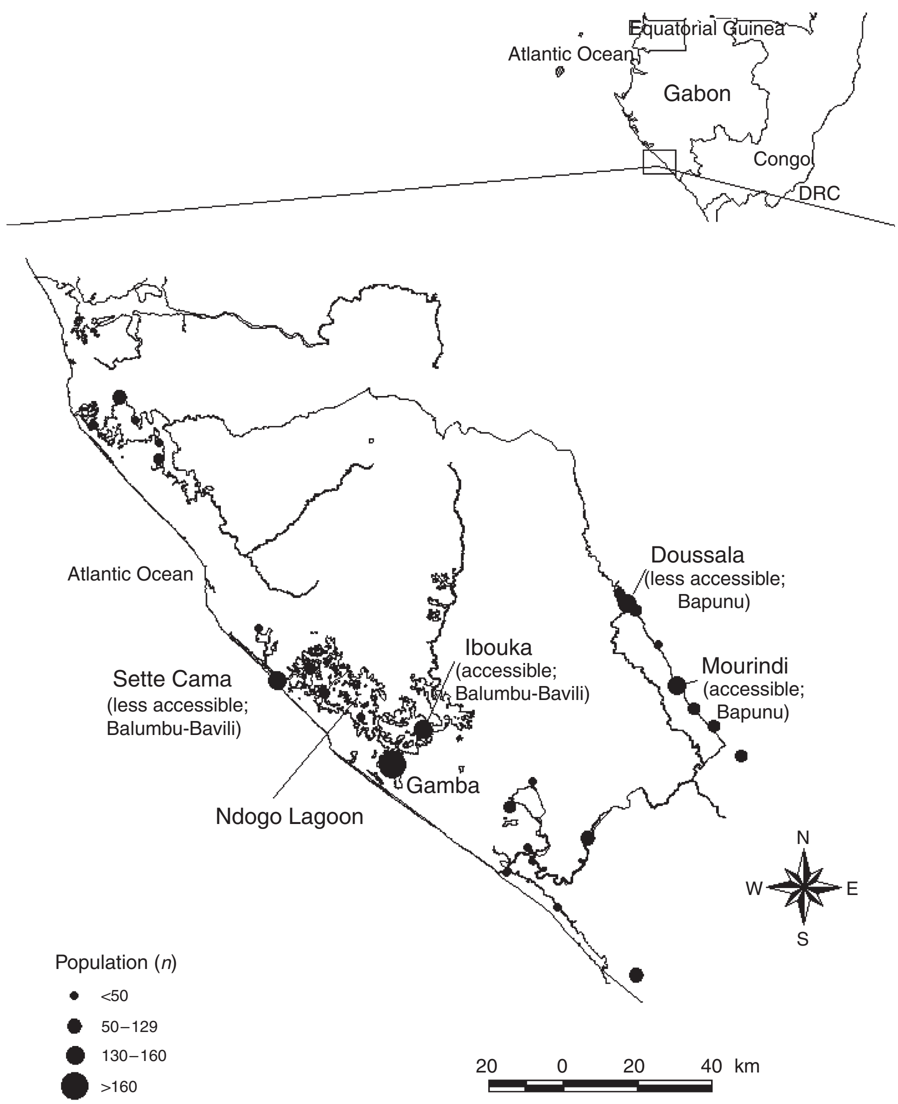

Fig. 1 The Gamba Complex of Protected Areas and location of selected communities

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prior to the actual survey, she informed villagers and local authorities, obtained their verbal approval and invited all households to participate, asking them not to change their pattern of food consumption[13,14]. Moreover, during the actual survey in each season, verbal consent was obtained from each household. The present study was also part of a larger project implemented by a conservation organization and for which an agreement had been signed with the government.

Training

Nine local surveyors and a Peace Corps biologist were trained by the main author on the objectives of the survey, its relevance and standardization of the methods for data collection (e.g. food weighing, observations). All data collection forms were pre-tested, adjusted and finalized during the two-week training. All surveyors were literate, fluent in local languages and motivated to participate. The biologist also functioned as a deputy to the principal investigator.

Data collection

The survey was carried out during each of the two major rainy and dry seasons (February–April and May–September, 2000). Each village was visited once during each season. Each visit lasted at least 16 d to encompass two periods of 7 d so as to cover all households. All surveyors lived in the village during the survey and the same surveyors were involved throughout. The main author reviewed all recorded data daily.

Anthropometric data

All individuals were weighed with a Uniscale (150 kg maximum, ±0·1 kg precision; UNICEF, Copenhagen, Denmark) before breakfast on the first day of the survey in each season. All measures were taken without shoes and with minimum clothing. For persons aged 24 months or older, height was measured vertically with a standardized board (0–200 cm, ±0·1 cm precision; Lindells, Malmo, Sweden). For those younger than 24 months, length was measured horizontally using a locally made board and a fixed non-extensible metric tape (0–152 cm, ±0·1 cm precision)[15].

Food intake

Food intake cannot be estimated without error[16]. The weighing method provides the most accurate estimate of an individual's food intake[13,14]. Moreover, it obviates the population's probable reluctance to disclose information such as that on bushmeat consumption. No validated FFQ exists for the area.

Dietary intake can show important variations from day to day and between seasons[17]. A single, daily measurement generally provides a poor estimate of the true nutrient intake of an individual[16,17]. The minimum number of days required for a good estimate of the usual intake of energy and macronutrients ranges from 4 to 23 d; for vitamin A, more than 50 d might be necessary[17–19]. We sought an estimate of the usual intake of individuals as opposed to that of a group. The expected variation was unknown. From an examination of studies in similar areas, practical considerations and our knowledge of habits in the area, it was decided to study seven consecutive days of intake. Because of the expected seasonal variation, it was further decided to repeat the study in the two major seasons (total 14 d). Among nutrients, energy, protein, Fe and vitamin A were of particular interest. They are often among the most limiting and many wildlife species could be important sources of protein and Fe.

In each season, four teams of two surveyors were each assigned to survey two or three households for one week while the biologist was assigned to one. A 7 d food consumption survey, as described by Pekkarinen[13], was carried out for each individual in every household. All ingredients included in food preparation as well as cooked individual portions, individual and household leftovers, and snacks or meals taken outside the village were weighed (4 kg maximum, ±0·001 kg; Acculab, Newtown, PA, USA). For each breast-fed child, each nursing period taking place between 05.30 and 23.30 hours was recorded. One surveyor was exclusively assigned to follow any individual away from the village for less than 36 h and to weigh the food that he/she consumed. Unlike in many African settings, the Gabonese eat from individual plates/bowls.

Physical activity

Each day, the surveyors classified the activities performed by each adult (≥20 years) into one of three categories: (i) individual was away from his house to farm/fish/hunt/gather; (ii) stayed in the village doing activities like cooking, cleaning or fetching water; and (iii) did not perform any of the previous activities (e.g. sick). Each day, the main author visited each household to gather similar information as a reliability check. Physical activity levels were assigned as follows[20]:

1. Vigorous: category (i) for >3 d/week.
2. Active: category (i) for ≤3 d/week or category (ii) for >3 d/week.
3. Light: category (ii) for ≤3 d/week or category (iii) for >3 d/week.

Sociodemographics, health, food security and care

Two semi-structured interviews were conducted: (i) with the male head of each household together with his wife and (ii) privately with the latter and any wife and woman caregiver of a child <5 years of age in the household. The first interview collected sociodemographic data for each household member (e.g. age, sex, schooling).

Both interviews collected data on individual health status, care practices, food security and the health environment (e.g. access to safe water and sanitation, housing). Age was confirmed with the identity or the health card. Data were also collected through observation (e.g. health status) and casual probing.

Data analysis

Nutritional status

For children <5 years of age, height-for-age (stunting), weight-for-height (wasting) and weight-for-age (underweight) indices were derived with the WHO Anthro 2005 software version Beta (2006; WHO, Geneva, Switzerland), which compares measurements with the WHO growth standards[21]. Children with indices below -1 SD from the median reference values (*Z*-score <-1) were considered undernourished, since mild and moderate undernutrition is a contributing cause of deaths in about 50 % of children <5 years of age[22,23]. In older children and adolescents (5–19 years), BMI-for-age percentile was estimated and compared with the reference values from the Centers for Disease Control and Prevention (CDC)[24] using the Epi Info software version 2002 (CDC, Atlanta, GA, USA). A value below the 5th percentile indicated thinness[15]. In adults, including lactating women, BMI $< 18{\cdot}5\,kg/m^2$ indicated underweight[15]. Pregnant women (*n* 11) were not assessed.

Health status

Each individual's health status was assessed on the basis of whether or not he/she was ill during the days surveyed in each season and on the nature and duration of each illness. Scores were assigned as follows: (i) 1·5 = individual was not sick; (ii) 1·0 = had a cold, flu, rheumatism or back pain; (iii) 0·5 = had diarrhoea, fever, parasites or toothache; and (iv) 0 = had an illness from each of categories (ii) and (iii) at the same time (e.g. flu with fever). The score was multiplied by the number of sick days (0 to 7). The maximum score in each season was 10·5 (1·5 × 7 d), while the minimum was 0. Using data from both seasons, the mean score was calculated for each individual.

Food and nutrient intake

Each breast-fed child was classified according to the daily frequency of breast-feeding: (i) 1–3 times; (ii) 4–6 times; or (iii) ≥7 times. His/her daily intake of breast milk was then estimated based on Brown *et al.*'s classification[25] regarding a low, average and high intake of breast milk. The quantities of food consumed by each individual were entered into the WorldFood Dietary Assessment software version 2.0 (1999; University of California, Berkeley, CA, USA) to calculate the average daily food and nutrient intakes. The nutritive value of foods not originally included was added to the database from information on labels (for eight of 209 foods) or from other sources (sixteen foods)[26–29].

Anthropometric data as well as food and nutrient intakes were transferred to the SPSS statistical software package version 13·0 (2004; SPSS Inc., Chicago, IL, USA) for further analysis. All other data were entered directly into SPSS. Duplicate coding of a random sample of 10 % was carried out and the necessary adjustments made.

Satisfaction of nutrient requirements

Nutrient requirements were estimated following the WHO/FAO recommendations for energy[20], protein[30], vitamin A and Fe[31] for all age groups except for children aged 0–23 months, where the most recent update was used[32]. The degree of satisfaction (%) of nutrient requirements was calculated by comparing the 7 d mean daily individual intakes with the estimated individual requirements (recommended dietary allowance for Fe and protein, recommended safe intake for vitamin A and recommended level of dietary energy intake for energy).

Prevalence of inadequate intakes

The proportion of the population at risk of inadequacy for protein and vitamin A was estimated by calculating the proportion of individuals below the Estimated Average Requirements (EAR)[30,31,33]. The prevalence of inadequate intake of Fe was assessed using the full probability approach because the distribution of the requirements is asymmetrical[33]. No information was available on the range of usual intakes associated with requirement percentiles for a diet with 10 % and 5 % of bioavailable Fe. Therefore, the assessment of the prevalence of inadequate intake of Fe was based on a diet with 18 %, except for children aged <1 year, where a diet with 10 % was available[33]. It was not assessed for children aged <6 months (both seasons, *n* 13) nor for pregnant and lactating women (*n* 35). The proportion of individuals with energy intakes below 100 % and 75 % of their requirements was simply assessed by comparing individual intakes with the recommended level of daily energy intake[20]. Data were adjusted for the day-to-day within-person variation in order to better reflect the inter-person variability of intakes[33].

Nutrient adequacy

In each season, a global score of nutrient adequacy was calculated for each individual by adding his/her mean degree of satisfaction of requirements for each of the four nutrients and dividing the total by 100, for a maximum score of 4. The maximum attributed to each nutrient was 100 % even when the percentage of satisfaction was higher as there is no known advantage to consuming more than required, except perhaps for vitamin A and Fe which can be stored. A global score for both seasons was estimated from the 14 d mean degree of satisfaction of requirements for the four nutrients.

Table 1 Sociodemographic characteristics of the population by location and season: non-random sample from the Gamba Complex of Protected Areas, Gabon, 2000

	Continental villages								Coastal villages								All villages			
	Rainy				Dry				Rainy				Dry				Rainy		Dry	
	n	%	Mean	SE	*n*	%	Mean	SE	*n*	%	Mean	SE	*n*	%	Mean	SE	*n*	%	*n*	%
Households	49				49				41				37				90		86	
Individuals	256				289				221				221				477		510	
Male		46				48				45				50				46		49
Female		54				52				55				50				54		51
Age			29·4	1·5			26·5	1·4			28·5	1·7			27·3	1·1				
0–23 months		5				8				5				6				5		7
24–59 months		8				9				9				10				9		10
5–9 years		12				12				14				15				13		13
10–19 years		24				26				24				22				24		24
20–59 years		34				32				28				27				31		30
≥60 years		16				13				20				20				18		16
Mean household size			5·4	0·6			6·0	0·5			5·4	0·4			5·9	0·7	5·4	0·4†	6·0	0·4†
Schooling of household head																				
None		42				43				34				38				39		40
1–3 years		17				16				22				24				19		20
4–6 years		29				27				29				30				29		28
≥7 years		12				14				15				8				13		12
Activity level*																				
Vigorous		19				14				16				15				18		14
Active		79				85				81				81				80		84
Light		2				1				3				4				2		2

*For adults ≥20 years.
†SE.

Statistical analysis

Normality in the distribution pattern was examined by visual inspection of the probability plots and with the Kolmogorov–Smirnov test. Homogeneity of the variance was assessed with the Levene test. When necessary, logarithmic and square-root transformations were applied to obtain normal distribution patterns and homoscedasticity. For the consumption of major food groups, a value of 0·5 was added before the logarithmic transformation to avoid zero scores.

For continuously distributed variables, a two-factor ANOVA was used to assess differences by season and location and their interaction. *Post hoc* comparisons used the Least Significant Difference test. The *t* test was performed to assess differences between two means. For categorical variables, the χ^2 test of independence was used to estimate differences in their distribution. Logistic regression was used to estimate the ability of dietary adequacy and health status to predict nutritional status. The goodness-of-fit of the final model was assessed by the Hosmer–Lemeshow test and the power of discrimination was analysed with the area under the receiver-operating characteristic curve. For all analysis, a probability value of 0·05 was accepted as significant.

Results

Population

Approximately 500 individuals in some ninety households participated in the survey during each season (Table 1). On average, 92 % of individuals present in the villages and 95 % of households were involved in both seasons. Others refused to participate mainly because they were unwilling to have their food weighed. Of participant-days surveyed (6909), 6 % were discarded for reasons such as the individual leaving before the end of the survey (160 participant-days), absence for more than 36 h (128 participant-days) or apparent non-reliability of data* (121 participant-days). The distribution of the population on most sociodemographic characteristics was similar in all villages and generally in accordance with that described in the Demographic and Health Survey[6]. About 40 % of household heads had no schooling and over 80 % of adults had an active level of physical activity. Since there was no systematic difference between the more and less accessible villages with regard to nutritional status and the satisfaction of nutrient requirements, data were merged into 'coastal' and 'continental' villages for further analysis.

Nutritional status

Children <5 years old were separated into two groups, 0–23 months and 24–59 months, given their different susceptibility to undernutrition. Overall, undernutrition was observed in all age groups. With the exception of children aged 24–59 months, there was no significant difference in prevalence between seasons, location

* For example, meal components such as sauce and meat not weighed separately or food weight appeared incorrect.

Table 2 Prevalence (%) of undernutrition in each age group by location and season: non-random sample from the Gamba Complex of Protected Areas, Gabon, 2000

	Continental villages				Coastal villages				All villages			
	Rainy		Dry		Rainy		Dry		Rainy	Dry	Both*	
Age group	*n*	%	*n*	%	*n*	%	*n*	%	%	%	*n*	%
0–23 months	13		21		11		13		(*n* 24)	(*n* 34)	41	
HAZ ≤ −2		(2)‡		19·0		(2)		(2)	16·7	17·6		14·6
HAZ ≤ −1		38·5		42·0		45·5		23·1	41·7	35·3		34·1
WHZ ≤ −2		–		14·3		(1)		–	(1)	8·8		4·9
WHZ ≤ −1		15·1		38·1		27·3		23·1	20·8	32·4		29·3
WAZ ≤ −2		–		19·0		(1)		–	(1)	11·8		9·8
WAZ ≤ −1		23·1		38·1		36·4		23·1	29·2	32·4		26·8
24–59 months	21		27		20		23		(*n* 41)	(*n* 50)	63	
HAZ ≤ −2		42·9§		11·1		30·0		17·4	36·6	14·0		20·6
HAZ ≤ −1		71·4		55·6		75·0		52·2	73·2	54·0		60·3
WHZ ≤ −2		–		11·1		–		–	–	6·0		1·6
WHZ ≤ −1		(2)		29·6		(2)		(2)	9·8	20·0		17·5
WAZ ≤ −2		(2)		11·1		15·0		(1)	12·2	8·0		11·1
WAZ ≤ −1		57·1		48·1		55·0		47·8	56·1	48·0		49·2
5–9 years	32		35		32		33		(*n* 64)	(*n* 68)	82	
BMI-for-age < 5th percentile		25·0		32·4		9·4		12·1	17·2	23·5		20·7
10–19 years†	62		75		51		49		(*n* 114)	(*n* 124)	169	
BMI-for-age < 5th percentile		9·8		13·3		21·1		18·4	15·0	15·3		14·8
20–59 years†	84		90		59		58		(*n* 149)	(*n* 152)	194	
BMI < 18·5 kg/m^2		12·9		13·3		6·9		12·1	10·5	12·8		9·3
≥60 years	40		38		45		44		(*n* 85)	(*n* 82)	101	
BMI < 18·5 kg/m^2		32·5		26·3		24·4		25·0	28·2	25·6		25·7

HAZ, height-for-age Z-score; WHZ, weight-for-height Z-score; WAZ, weight-for-age Z-score.
*For each individual present in both seasons, mean nutritional status was calculated; some were present only in one season (e.g. newborns).
†Nutritional status of pregnant women was not assessed (*n* 1, 10–19 years; *n* 10, 20–59 years).
‡When the number of individuals in a category was ≤2, the percentage was not calculated.
§Difference in distribution between seasons in continental villages ($P = 0·014$).

(Table 2) or gender (results not shown). As compared with the dry season, more children aged 24–59 months were stunted in the rainy season. Their mean height-for-age Z-score was also lower (rainy −1·4 (SE 0·1) *v.* dry −1·0 (SE 0·1), $P = 0·017$; results not shown). Children <5 years old showed the highest rates of undernutrition, followed by the elderly, children aged 5–9 years, adolescents and adults. The mean BMI was 22·1 (SE 0·2) kg/m^2 in adults and 20·8 (SE 0·3) kg/m^2 for the elderly. In children <5 years old, mean height-for-age Z-score was −0·9 (SE 0·1), mean weight-for-height Z-score was −0·3 (SE 0·1) and mean weight-for-age Z-score −0·8 (SE 0·1). About 9 % of adults aged 20–59 years and 26 % of the elderly were undernourished. No clinical signs of severe undernutrition were apparent.

Overall, 14·9 % and 11·9 % of adults and the elderly showed BMI ≥ 25·0 kg/m^2, while one child aged 5–9 years and two adolescents were at risk of overweight (BMI-for-age > 85th percentile)[15]. There were no children <5 years old with a mean weight-for-height Z-score above +2 (results not shown).

Health status

No illness was reported during the days surveyed for about half of the children aged <5 years or for most individuals in other groups, nor were they obviously ill (Table 3). No difference was observed between age groups in the mean score of health status among sick individuals. Individuals were therefore eventually classified as either sick or not sick.

Food intake

Tables 4 and 5 show the arithmetic means of the quantity of each food group consumed daily per capita; analyses were however done on transformed data. Tubers/cereals/breads was by far the main food group consumed, followed by alcoholic beverages (Table 4). Most of the fish/shellfish was consumed in coastal villages, while more of the meat/chicken/eggs was eaten in continental villages. The intake of fruits and vegetables was far below the 400 g/d recommended[34]. Fortified foods were almost non-existent. The use of nutrient supplements was absent.

Overall, tubers, cereals and breads provided most of the energy (Table 5). They also contributed approximately half of the Fe and an important proportion of protein and pro-vitamin A. Vegetables contributed approximately 50 % of the vitamin A in each season (between 97·0 (SE 8·8) and 314·7 (SE 15·7) retinol equivalents (RE)/4184 kJ (1000 kcal)) and somewhat more in continental (between 215·0 (SE 11·2) and 314·7 (SE 15·7) RE/4184 kJ) as compared with coastal settings (between 97·0 (SE 8·8) and 160·0 (SE 11·1) RE/4184 kJ; results not shown). Together, fish/shellfish and meat/chicken/eggs provided about 10 % of vitamin A

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Table 3 Nutrient adequacy and health status* for each age group by location and season: non-random sample from the Gamba Complex of Protected Areas, Gabon, 2000

	Continental villages						Coastal villages						All villages								
	Rainy			Dry			Rainy			Dry			Rainy			Dry			Both†		
Age group	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE
0–23 months																					
Nutrient adequacy	13	3·2	0·2	21	3·3	0·1	11	2·9	0·1	13	3·2	0·1	24	3·0	0·1	34	3·3	0·1	41	3·2‡	0·1
Health status																					
Not sick	9			9			3			4			12			13			17		
Sick	4	8·3	0·9	12	6·0	0·8	8	7·3	1·1	9	6·5	0·9	12	7·6	0·8	21	6·3	0·6	24	7·5	0·3
24–59 months																					
Nutrient adequacy	21	2·9	0·1	27	2·7	0·1	20	2·9	0·1	23	3·1	0·1	41	2·9	0·1	50	2·9	0·1	63	2·9	0·1
Health status																					
Not sick	11			8			17			17			28			25			33		
Sick	10	6·8	0·7	19	6·7	0·6	3	7·3	1·0	6	7·9	0·6	13	6·9	0·6	25	7·0	0·5	30	7·5	0·4
5–9 years																					
Nutrient adequacy	32	2·9	0·1	35	2·9	0·1	32	2·9	0·1	33	3·2	0·1	64	2·9	0·1	68	3·0	0·1	82	3·0	0·1
Health status																					
Not sick	30			29			29			30			59			59			69		
Sick	2	8·8	1·3	6	7·2	0·8	3	8·2	0·3	3	7·7	0·7	5	8·4	0·5	9	7·3	0·5	13	8·2	0·5
10–19 years																					
Nutrient adequacy	62	2·7	0·1	75	2·6	0·1	52	2·6	0·1	49	2·9	0·1	114	2·7	0·1	124	2·7	0·1	169	2·7	0·1
Health status																					
Not sick	61			72			45			47			106			119			156		
Sick	1	8·5		3	6·8	1·7	7	7·1	1·0	2	7·5	0·5	8	7·3	0·9	5	7·1	0·9	13	8·4	0·3
20–59 years																					
Nutrient adequacy	88	3·1	0·1	93	3·1	0·1	61	3·0	0·1	59	3·0	0·1	149	3·1	0·1	152	3·1	0·1	194	3·1	0·1
Health status																					
Not sick	73			81			49			45			122			125			144		
Sick	15	8·1	0·2	12	7·1	0·8	12	6·7	0·6	14	6·5	0·6	27	7·5	0·3	27	6·8	0·5	50	8·3	0·2
≥60 years																					
Nutrient adequacy	40	3·2	0·1	38	3·3	0·1	45	3·0	0·1	44	3·4	0·1	85	3·1	0·1	82	3·3	0·1	101	3·3	0·1
Health status																					
Not sick	32			30			37			28			69			58			68		
Sick	8	6·8	0·6	8	6·9	0·6	8	6·3	0·6	16	6·7	0·4	16	6·6	0·4	24	6·8	0·3	33	7·9	0·4

*Mean score of health status was calculated only for sick individuals.
†Refers to the mean of each individual's score for each week of the survey.
‡Difference between age groups ($P < 0{\cdot}05$).

(between 17·8 (SE 1·4) and 24·6 (SE 1·7) RE/4184 kJ), 58% of protein and 26% of Fe.

All children aged <6 months were breast-fed (*n* 13), although only two exclusively; breast milk probably contributed approximately 90 (SE 3) % of their energy intake. About 50% of children aged 6–23 months (*n* 41) were breast-fed. Breast milk was estimated to provide 48 (SE 8) % of energy in children aged 6–11 months and 10 (SE 5) % in children aged 12–23 months.

Nutrient intakes and satisfaction of requirements

Overall, protein provided 14 (SE 0·1) % of energy, fat 21 (SE 0·2) % and carbohydrates 65 (SE 0·5) %. Populations living in coastal villages had better energy intakes (Table 6) and generally better satisfied their requirements (Table 7), particularly in the dry season. Nevertheless, energy requirements were generally far from satisfied in all groups.

Protein and Fe intakes per 4184 kJ (1000 kcal) did not vary with season. However, in each season, protein intake was higher in coastal villages (Table 6). Although generally fulfilled, protein requirements were better satisfied in coastal villages as well as in the dry season (Table 7). Vitamin A intake (Table 6) and the satisfaction of requirements (Table 7) were generally low, although higher in continental villages and in the rainy season. Fe intake was highest in continental villages (Table 6) although Fe requirements were far from satisfied, particularly among children and adolescents (Table 7). In both seasons, Fe requirements of males aged 10–19 years and 20–59 years were better satisfied (between 60 (SE 3) % and 101 (SE 4) %) than those of females (between 32 (SE 3) % and 57 (SE 3) %, $P < 0{\cdot}001$; results not shown).

Prevalence of inadequate intakes

Between 37% and 100% of individuals did not satisfy their energy requirements, whereas between 9% and 92% did not attain 75% (Figs 2 and 3). The prevalence of inadequate intake of protein was much lower than that of energy but still a problem, especially among adolescents in continental villages (Figs 2 and 3). With the exception of continental villages during the rainy season, at least 60% of individuals had intakes of vitamin A below the EAR. The prevalence of inadequate intake of Fe appeared lower than that for energy or vitamin A, although still of concern; it was generally highest among children aged <5 years.

Table 4 Daily per capita intake (g) of each food group by location and season: non-random sample from the Gamba Complex of Protected Areas, Gabon, 2000

	Continental villages				Coastal villages				All villages			
	Rainy (*n* 256)		Dry (*n* 289)		Rainy (*n* 221)		Dry (*n* 221)		Rainy (*n* 477)		Dry (*n* 510)	
Food group	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Tubers/cereals/breads	648·2	24·0	570·2	33·3	480·7§	24·2	645·9	61·0	571·9	19·2	602·8	32·4
Meat/chicken/eggs	61·0‡	7·6	44·2‡	7·3	23·0	4·4	16·5	4·8	43·6‖	5·0	32·3	4·9
Fish/shellfish	39·8‡	6·4	38·3‡	4·6	188·2	14·3	211·4	28·5	107·4	10·8	112·8	15·5
Vegetables	92·8‡,§	7·8	46·5	6·0	34·5	5·6	50·2	12·2	66·2	5·8	48·1	6·3
Fruits	47·7	12·4	41·9	9·8	10·3	2·2	36·4	16·0	30·6	7·1	39·6	8·8
Nuts/beans	15·7	2·5	10·0	2·1	3·7	0·9	3·7	1·5	10·2	1·6	7·3	1·4
Milk/cheese*	2·4	0·9	1·2	0·5	3·8	2·1	3·5	0·8	3·0	1·1	2·2	0·5
Sugars/sweets	14·0‡	1·8	21·6‡	3·6	17·0	2·9	61·3	14·5	15·4§	1·7	38·7	6·9
Fats/oils	1·1	0·3	4·0	1·4	1·3	0·4	2·5	1·9	1·2	0·2	3·4	1·1
Non-alcoholic beverages	13·6	3·4	5·6	1·4	39·7	5·5	65·6	7·0	25·5	3·4	31·4	4·5
Mixtures (sauces)	5·3‡	1·6	1·4‡	0·6	21·3	7·2	3·8	1·3	12·6§	3·5	2·4	0·2
Infant foods	0·3	0·2	–	–	0·3	0·2	1·4	0·8	0·3	0·1	0·6	0·4
Alcoholic beverages†	175·6‡	37·3	166·6‡	29·7	245·2	37·8	319·5	51·3	207·7	27·0	233·2	28·9

*Includes breast milk.
†Means calculated for adults ≥20 years.
‡Difference between locations ($P < 0·01$).
§Difference between seasons ($P < 0·01$).
‖Difference between seasons ($P < 0·05$).

Nutrient adequacy

Children aged 0–23 months and the elderly had the best scores of global nutrient adequacy, while adolescents had the lowest (Table 3). Adult (mean score 3·3 (SE 0·1), *n* 90) and adolescent males (2·9 (SE 0·1), *n* 85) had better scores than their female counterparts (2·9 (SE 0·1) and 2·5 (SE 0·1), *n* 104 and *n* 84, $P = 0·000$; results not shown).

Association between nutritional status, nutrient adequacy and health status

In logistic regression analyses, both the global score on nutrient adequacy (continuous) and health status (not sick) predicted nutritional outcome (Table 8, model 1). When age group was added (model 2), health status was no longer significant and the odds for nutrient adequacy increased (OR = 1·64, 95 % CI 1·13, 2·39). Being a child aged 0–9 years or elderly appeared to be associated with a greater risk of undernutrition. Introducing gender and location (or ethnic group) did not change the results (not shown). The discriminative power of the final equation was acceptable at 0·72 (well-nourished *v.* undernourished)[35]. Similar results were obtained when weight-for-age was substituted as an indicator of undernutrition for children aged <5 years (results not shown).

Discussion

Undernutrition is important in the Complex, especially among the young, as opposed to overweight which affects only adults and the elderly. Using the criterion of *Z*-score ≤−1 (mild undernutrition), 50 % of children <5 years of age were stunted, 22 % were wasted and 40 % were underweight. In a normal population, only 2·3 % of children would be expected to have *Z*-score ≤−2 (moderate and severe undernutrition[15]). However, in the present study, this was the case for 18 % of the under-fives for stunting and 11 % for underweight, a serious concern given their link to child mortality[22,23]. Before 24 months, 15 % were stunted, a particularly concerning situation given that it is nearly irreversible after the age of 2–3 years.

As suggested by the logistic regression results, nutrient adequacy was a more important predictor of nutritional status than health status after controlling for age. However, the majority of individuals were not ill during the survey; in addition, our measure of health was highly summarized and did not capture past illnesses. Yet, undernutrition did not always parallel results on the prevalence of inadequate intakes of energy or on global nutrient adequacy. Overall, adults (20–59 years) had the lowest rate of undernutrition but a very high prevalence of inadequate intake of energy, whereas the elderly had a high prevalence of undernutrition with the best score on nutrient adequacy.

It is unlikely that the dietary intake of adults was underestimated as households were under continuous surveillance. Given our prior knowledge of this population and our relationship with them, it is also unlikely that they changed their diet because of our presence. Moreover, we did investigate their diet for 7 d in each season, making it difficult for them to restrict their intakes for more than a day or two as they had to maintain their regular activities. Their energy requirements could have been overestimated either through an error in measuring height or physical activity, or by basing estimates on desirable weight instead of actual weight. It is unlikely that height was inaccurate since we obtained a correlation

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Table 5 Contribution (%) of each food group to nutrient intake by location and season: non-random sample from the Gamba Complex of Protected Areas, Gabon, 2000

	Energy				Protein				Vitamin A/pro-vitamin A				Fe			
Continental villages	Rainy (*n* 256)		Dry (*n* 289)		Rainy (*n* 256)		Dry (*n* 289)		Rainy (*n* 256)		Dry (*n* 289)		Rainy (*n* 256)		Dry (*n* 289)	
Food group	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Tubers/cereals/breads	65·1	1·0	68·6‡	1·0	30·1§	0·9	32·3§	0·9	25·3	1·5	26·3§	1·5	47·2†	1·0	56·9†	0·9
Meat/chicken/eggs	7·1†	0·6	6·4†	0·4	34·4†	1·6	31·5†	1·4	1·3†	0·3	1·8†	0·4	21·7†	1·2	22·6†	1·1
Fish/shellfish	3·4†	0·3	3·9†	0·2	8·8†,§	1·1	25·7†	1·0	3·3†	0·4	2·2†	0·3	6·0†	0·4	6·1†	0·3
Vegetables	8·8†	0·4	5·3†	0·3	4·4†	0·3	0·9†	0·1	60·4†	1·9	55·5†	1·9	10·1†	0·6	3·9	0·2
Fruits	1·2†	0·2	2·3†	0·2	1·1†	0·1	1·3†	0·1	0·8	0·2	1·2†	0·2	2·7†	0·4	2·6†	0·2
Nuts/beans	3·2†	0·3	2·5†	0·2	5·5†	0·5	2·5†	0·3	0·3	0·1	2·4†	0·6	6·4	0·5	2·7	0·3
Milk/cheese*	2·9	0·9	4·6‡	1·1	2·9	0·9	4·5‡	1·1	3·4	1·1	4·9	1·2	1·5	0·7	2·5‡	0·7
Sugars/sweets	2·6‡	0·2	2·5‡	0·2	–	–	–	–	–	–	–	–	–	–	–	–
Fats/oils	1·0	0·4	1·0†	0·1	–	–	–	–	0·2	0·1	3·1†	0·8	–	–	–	–
Alcoholic beverages	2·6	0·5	1·9†	0·3	0·8	0·4	0·4	0·1	–	–	–	–	1·8	0·3	1·3	0·3
Mixtures	1·5b†	0·2	0·9†	0·1	1·6†	0·3	0·6†	0·1	4·6†	0·8	2·7†	0·5	1·2†	0·2	0·6	0·1
Infant foods	0·3	0·2	–	–	0·4	0·3	–	–	0·4	0·3	–	–	0·8	0·5	–	–
Coastal villages	Rainy (*n* 221)		Dry (*n* 221)		Rainy (*n* 221)		Dry (*n* 221)		Rainy (*n* 221)		Dry (*n* 221)		Rainy (*n* 221)		Dry (*n* 221)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Tubers/cereals/breads	66·2	0·9	65·3	0·9	28·7	1·0	27·1	0·8	25·8	1·5	32·8	1·7	58·1	1·2	63·1	1·3
Meat/chicken/eggs	2·2	0·2	1·4	0·2	7·5§	0·8	4·3	0·5	3·8	0·7	5·2	0·7	11·4	1·1	7·9	1·0
Fish/shellfish	12·9	0·5	12·2	0·5	55·8	1·4	58·1	1·2	13·1	1·3	10·6	1·0	16·6	0·8	15·6	0·7
Vegetables	4·2	0·3	3·1	0·2	1·4	0·1	2·7	0·4	45·1	2·1	31·9	1·9	5·8	0·4	3·5	0·3
Fruits	0·6	0·1	0·7	0·1	0·2	0·1	0·3	0·1	0·6	0·2	1·9	0·4	0·7	0·2	0·7	0·2
Nuts/beans	1·0	0·2	0·5	0·1	0·6	0·1	0·2	0·1	0·2	0·1	0·2	0·1	1·1	0·2	0·3	0·1
Milk/cheese*	1·6	0·6	1·7	0·6	1·5	0·5	1·6	0·6	1·7	0·5	2·5	0·7	0·3	0·1	0·3	0·2
Sugars/sweets	2·0	0·2	3·1	0·3	–	–	–	–	–	–	–	–	–	–	–	–
Fats/oils	0·5	0·1	0·5	0·1	–	–	–	–	0·4	0·1	0·1	0·1	–	–	–	–
Alcoholic beverages	3·5	0·5	3·5	0·5	0·4	0·1	0·7	0·1	–	–	–	–	1·6	0·3	2·4	0·5
Mixtures	4·6	0·3	6·8	0·3	3·1	0·4	3·7	0·4	8·7	0·9	13·7	1·3	2·7	0·3	3·5	0·3
Infant foods	0·4	0·3	0·9	0·4	0·6	0·4	1·2	0·6	0·6	0·4	0·9	0·6	0·8	0·6	1·6	0·8
All villages	Rainy (*n* 477)		Dry (*n* 510)		Rainy (*n* 477)		Dry (*n* 510)		Rainy (*n* 477)		Dry (*n* 510)		Rainy (*n* 477)		Dry (*n* 510)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Tubers/cereals/breads	65·6§	0·7	67·2	0·7	29·5	0·7	30·0	0·6	25·5§	1·1	29·1	1·1	52·1§	0·8	59·7	0·6
Meat/chicken/eggs	4·8	0·3	4·3	0·3	22·0	1·1	19·8	1·0	2·5	0·4	3·3	0·4	16·9	0·8	16·3	0·8
Fish/shellfish	7·8	0·3	7·5	0·3	35·9	1·1	39·7	1·1	7·8	0·7	5·8	0·5	10·8	0·5	10·1	0·4
Vegetables	6·7	0·3	4·3	0·2	3·0	0·2	1·7	0·2	53·3§	1·4	45·3	1·4	8·1§	0·4	5·8	0·2
Fruits	0·9	0·1	1·6	0·1	0·7	0·1	0·9	0·1	0·7	0·1	1·5	0·2	1·7	0·2	1·8	0·1
Nuts/beans	2·2	0·2	1·6	0·1	3·2	0·3	1·5	0·2	0·3	0·1	1·5	0·4	4·0	0·3	2·7	0·2
Milk/cheese*	2·3	0·6	3·3	0·7	2·3	0·6	3·3	0·7	2·6	0·6	3·9	0·8	1·0	0·4	1·6	0·4
Sugars/sweets	2·3	0·1	2·8	0·1	–	–	–	–	–	–	–	–	–	–	–	–
Fats/oils	0·7	0·2	0·8	0·1	–	–	–	–	0·3	0·1	1·8	0·4	–	–	–	–
Alcoholic beverages	3·0	0·4	2·6	0·3	0·6	0·2	0·5	0·1	–	–	–	–	1·8	0·3	1·7	0·3
Mixtures	2·9	0·2	3·4	0·2	2·2	0·2	2·0	0·2	6·5	0·6	7·4	0·7	2·0	0·2	1·9	0·2
Infant foods	0·4	0·2	0·4	0·2	0·5	0·2	0·5	0·3	0·5	0·3	0·4	0·4	0·8	0·4	0·7	0·3

*Includes breast milk.
†Difference between locations ($P < 0·01$).
‡Difference between locations ($P < 0·05$).
§Difference between seasons ($P < 0·01$).

of 0·997 between the height of adults present in both seasons. Activity level could have been overestimated. More than 80 % of adults were classified as active which includes a broad range of activities, many of which were probably not that vigorous. However, we did not have enough data for further verification. Energy requirements calculated from either actual or desirable weight were practically identical (results not shown). Therefore, the

Table 6 Individual intakes of energy and nutrients by location and season: non-random sample from the Gamba Complex of Protected Areas, Gabon, 2000

	Continental villages				Coastal villages				All villages			
	Rainy (*n* 256)		Dry (*n* 289)		Rainy (*n* 221)		Dry (*n* 221)		Rainy (*n* 477)		Dry (*n* 510)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Energy (kJ)	5825*	102	5830*	91	6603	110	7548	110	6176†	75	6623	71
Energy (kcal)	1392·1*	24·4	1393·5*	21·8	1578·2	26·4	1803·9	26·4	1476·0†	18·0	1583·0	17·0
Protein (g/4184 kJ)	28·7*	0·2	29·0*	0·2	35·7	0·3	35·2	0·3	31·6	0·2	31·8	0·2
Vitamin A/pro-vitamin A (RE/4184 kJ)	514·0*	11·3	348·3*	7·0	272·3	6·5	204·2	4·9	384·5†	6·2	269·7	4·1
Fe (mg/4184 kJ)	6·6*	0·1	6·6*	0·1	5·7	0·1	5·6	0·1	6·2	0·1	6·1	0·1

RE, retinol equivalents·
*Difference between locations in each season ($P < 0{\cdot}01$).
†Difference between seasons ($P < 0{\cdot}01$).

Table 7 Degree of satisfaction (%) of energy and nutrient requirements for each age group by location and season: non-random sample from the Gamba Complex of Protected Areas, Gabon, 2000

	Continental villages				Coastal villages				All villages			
	Rainy		Dry		Rainy		Dry		Rainy		Dry	
Age group	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
0–59 months*	(*n* 34)		(*n* 48)		(*n* 31)		(*n* 36)		(*n* 65)		(*n* 84)	
Energy	91	3	89	3	84	3	107	3	88§	2	97§	2
Protein	120	3	123	3	156	5	191	5	135§	3	149§	3
Vitamin A/pro-vitamin A	110	5	102	4	56	3	77	4	80	2	89	3
Fe	48	4	48	4	35	4	47	4	42§	3	47§	3
5–9 years	(*n* 32)		(*n* 35)		(*n* 32)		(*n* 33)		(*n* 64)		(*n* 68)	
Energy	68	3	71	3	82	3	97	3	74	2	82	2
Protein	117	3	128	3	188	5	206	6	145	3	157	3
Vitamin A/pro-vitamin A	121	6	84	4	57	3	71	4	85	3	76	3
Fe	49	4	54	4	50	4	47	5	50	3	53	3
10–19 years	(*n* 62)		(*n* 75)		(*n* 52)		(*n* 49)		(*n* 114)		(*n* 123)	
Energy	56	3	56	2	58	3	81	3	57	2	66	2
Protein	92	2	93	2	128	3	159	4	107	2	117	2
Vitamin A/pro-vitamin A	127	4	85	3	53	2	70	3	85	2	78	2
Fe	50	3	53	3	43	3	54	4	46	2	54	2
20–59 years	(*n* 88)		(*n* 93)		(*n* 61)		(*n* 59)		(*n* 149)		(*n* 151)	
Energy	65	2	66	2	69	3	80	2	67	2	72	1
Protein	130	2	126	2	179	4	174	3	150	2	145	2
Vitamin A/pro-vitamin A	144	4	90	3	61	2	60	2	97	2	76	2
Fe	80	3	79	3	72	4	75	4	76	2	77	3
≥60 years	(*n* 40)		(*n* 38)		(*n* 45)		(*n* 44)		(*n* 85)		(*n* 82)	
Energy	73	3	76	3	77	3	96	3	75	2	85	2
Protein	120	3	131	3	158	4	194	5	136	2	155	3
Vitamin A/pro-vitamin A	129	5	99	5	62	3	87	4	93	3	93	3
Fe	98	5	96	6	77	6	98	6	88	4	97	4
All	(*n* 256)		(*n* 289)		(*n* 221)		(*n* 221)		(*n* 477)		(*n* 510)	
Energy	71	1	72†	1	74‡	1	92	1	70	1	75	1
Protein	120†	2	122†	1	167	2	189	2	132‡	3	142	1
Vitamin A/pro-vitamin A	119†	2	86†	2	55	2	67	2	97‡	2	75	1
Fe	65†	4	67	2	56	2	66	2	56	3	59	1

*The degree of satisfaction of Fe requirements was not assessed in children aged <6 months.
†Difference between locations ($P < 0{\cdot}01$).
‡Difference between seasons ($P < 0{\cdot}01$).
§Difference between age groups in each season ($P < 0{\cdot}01$).

discrepancy between nutritional status and the prevalence of inadequate energy intake in adults is probably due to our imprecise assessment of physical activity. Assuming the error is similar across the population, it is somewhat taken into account in the global score of nutrient adequacy; in addition, the latter also includes three other nutrients. The results are thus consistent with nutrient adequacy being a good predictor of nutritional status.

Among the elderly, we suspect that their diet improved because of the survey. Having people interested in their food could have led them to prepare more elaborate meals for increased attention. Contrary to younger adults, they were often living alone or as a couple and not as busy.

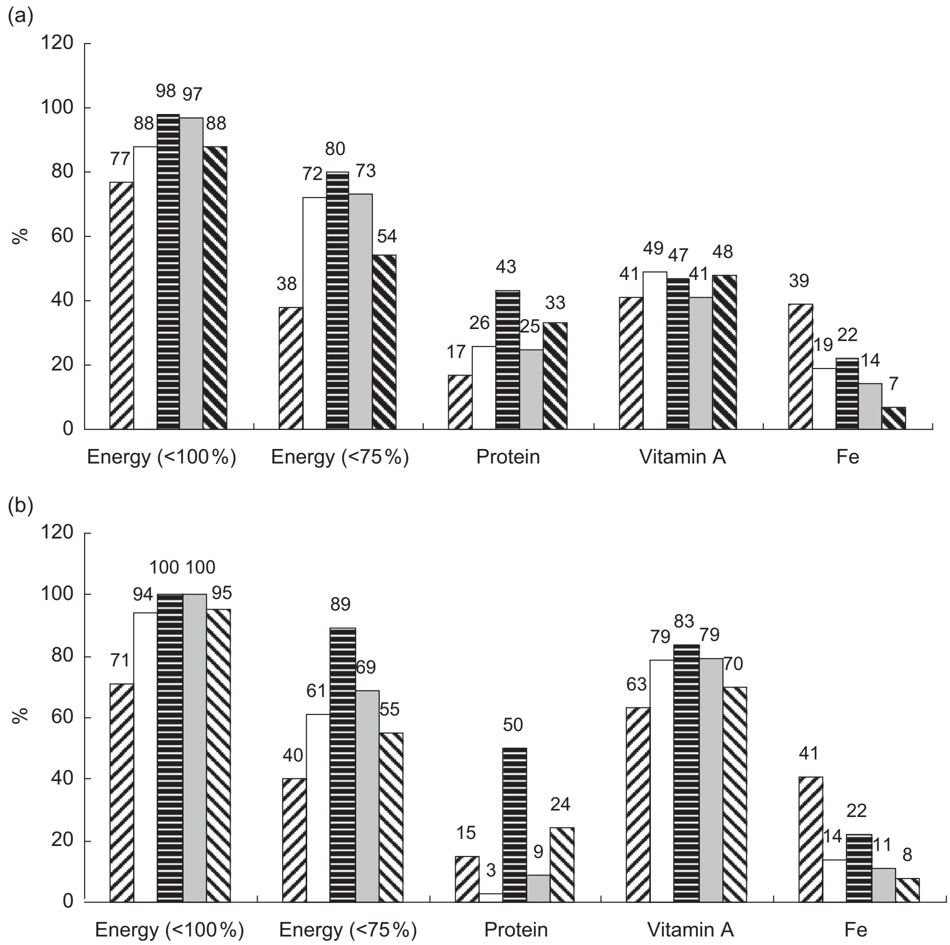

Fig. 2 Prevalence (%) of inadequate nutrient intakes by age group (▨, 0–59 months; □, 5–9 years; ▤, 10–19 years; ■, 20–59 years; ▧, ≥60 years) in continental villages in the rainy season (a) and the dry season (b): non-random sample from the Gamba Complex of Protected Areas, Gabon, 2000

If they did modify their diet, their satisfaction of requirements would be even lower than what was observed. However, it is likely that their physical activity was also overestimated, thus further corroborating our results.

Although breast milk provided most of the energy for children aged <6 months, other sources, mainly puréed staples, likely displaced the more nutrient-dense breast milk. While breast milk still provided about 50 % of energy for children aged 6–11 months, staples were the main complementary foods. The low rate of exclusive breast-feeding before 6 months, the subsequent low frequency of nursing and the low nutrient density of complementary foods interfere with good nutrition. The intake of breast milk was estimated as precisely as possible; however, it should still be interpreted cautiously.

While requirements can be used to assess the apparent adequacy of an individual's dietary intake, the EAR is the relevant reference to assess the proportion of a population at risk of protein and vitamin A inadequacy. Overall, our results on the prevalence of inadequate intake of energy, protein, Fe and vitamin A followed a pattern similar to those on the satisfaction of requirements. However, the prevalence of inadequate intake of Fe was likely underestimated, since the reference data used to assess this risk were based on a diet with 18 % of bioavailable Fe as no other data were available. It is likely that our population had a low risk of inadequate intake of protein. For vitamin A, those living in continental villages presented a moderate risk of inadequate intake during the rainy season.

Nevertheless, the prevalence of inadequate intakes for all nutrients examined is generally of concern. The deficit of energy is particularly striking. Many individuals of all ages, particularly adolescents, apparently do not eat enough. Although protein requirements were generally satisfied in all age groups, since energy requirements were largely unfulfilled, proteins were likely utilized to provide energy, probably creating a problem for children and adolescents. The very low intake of vitamin A, the fact that most of its sources were of vegetable origin and its high prevalence of inadequacy in most age groups could favour the development of infections, especially

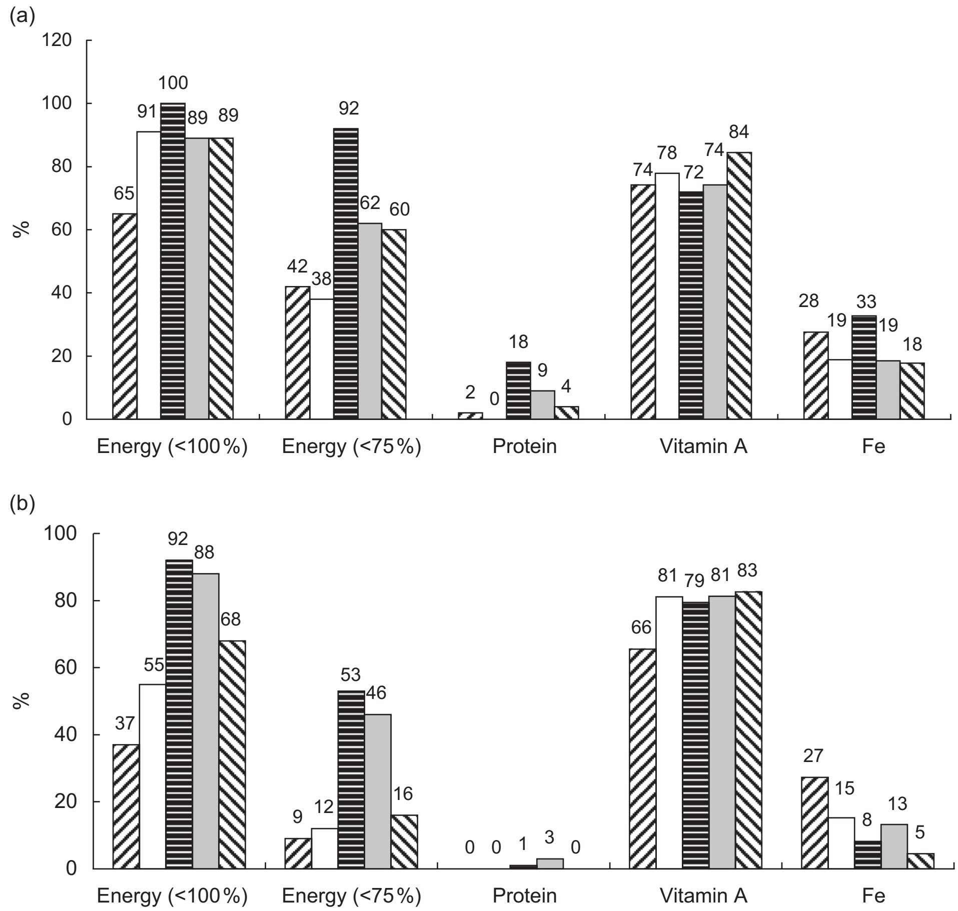

Fig. 3 Prevalence (%) of inadequate nutrient intakes by age group (, 0–59 months; , 5–9 years; , 10–19 years; , 20–59 years; , ≥60 years) in coastal villages in the rainy season (a) and the dry season (b): non-random sample from the Gamba Complex of Protected Areas, Gabon, 2000

Table 8 Immediate determinants of nutritional status* in a non-random sample from the population of the Gamba Complex of Protected Areas, Gabon, 2000

Model	Coefficient	*P* value	OR ratio	95 % CI
Model 1				
Constant	−0·174	0·746	0·841	
Nutrient adequacy	0·364	0·033	1·439	1·030, 2·009
Health status (not sick)†	0·549	0·009	1·731	1·149, 2·609
Model 2				
Constant	0·555	0·320	1·741	
Nutrient adequacy	0·497	0·009	1·644	1·131, 2·389
Age group (0–23 months)‡	−1·477	0·000	0·228	0·109, 0·477
Age group (24–59 months)‡	−2·408	0·000	0·090	0·049, 0·164
Age group (5–9 years)‡	−0·681	0·033	0·506	0·271, 0·946
Age group ≥60 years)‡	−1·105	0·000	0·331	0·187, 0·586

*Children aged <5 years with a length/height-for-age *Z*-score above −1 were considered well-nourished.
†Reference category: sick.
‡Reference category: adults (20–59 years).

among the most vulnerable[36]. The proportion of energy provided by fat could also have been a limiting factor for the absorption of pro-vitamin A. Among individuals who satisfied less than 75 % of their vitamin A requirements, fat provided 19 % of energy compared with 26 % among those with a higher intake. Both are, however, well within the recommended range (15–30 %)[34] and for example, green leaves, a source of pro-vitamin A, were always cooked with oil. While we were not able to estimate retinol activity equivalents, doing so would not likely improve the picture. Fe intakes were particularly deficient in groups whose requirements are especially high, also likely taking its toll on growth, development and work capacity[37]. Finally, it is possible that if each individual could eat enough of the

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same food to meet his/her energy requirements, their intake of vitamin A and Fe would be adequate.

Tubers, cereals and breads were major contributors to all nutrients. Meat/chicken/eggs in continental villages and fish/shellfish in coastal villages were important for protein and Fe, while vegetables were important for vitamin A. Much fish/shellfish, meat/chicken/eggs and many vegetables are natural resources. Other foods such as tubers generally require deforestation for agricultural purposes. If legislation prohibiting the extraction of these resources were enforced, the nutritional situation could be much worse.

Since the study was not carried out in a randomly selected sample of villages, the results cannot necessarily be generalized to the whole rural population of the Complex. Nevertheless, the sample was intentionally selected to represent the population of continental and coastal locations (ethnic group) and access to market although neither proved to have a major influence on the parameters studied. The length of the study could have been increased and the results might have been more precise. However, the prevalence of inadequate intakes would likely still be important. Many safeguards were also used to improve the reliability of data throughout their collection and analysis, including close monitoring of surveyors, daily revisions of data and double coding of a random sample of 10 % of data.

Conclusion

The present results provide an overview of the nutrition situation of the rural population living in the Complex. Inadequate intakes of nutrients are associated with undernutrition, particularly among children and the elderly. Among the former, improved breast-feeding practices would go a long way to improve nutritional status. In all groups, it appears that many individuals do not eat nearly enough food to satisfy even their energy requirements although much of their food does come from natural resources. This emphasizes the need to investigate this situation further to find ways to ensure that protection of natural resources will not be associated with harm to the well-being of local people.

The right to good nutrition has been recognized[38,39]. Undernutrition in all ages, but particularly in childhood, has severe and long-term consequences[40]. Undernutrition disempowers individuals by causing or aggravating illness. The potential intellectual and technical capacity of a population relies on enhanced nutrition. Conservation agencies cannot afford to create more protected areas without addressing the issue of the consequences for dwellers and neighbouring communities.

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