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NUTRITIONAL STATUS, ACTIVITY PATTERN, AND DIETARY INTAKE AMONG THE BAKA HUNTER-GATHERERS IN THE VILLAGE CAMPS IN CAMEROON

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ABSTRACT The nutritional status of 75 male and 73 female Pygmy hunter-gatheres were surveyed as well as the daily physical activity, energy and intake of major nutrients, and total energy expenditure were examined for two married couples of the Baka hunter-gatherers in the Cameroon. The average stature was intermediate relative to other Pygmy hunter-gatherers, and the subjects were generally well nourished. Despite the limited sample size and survey duration, the results indicated that the energy intake and energy expenditure of Cameroonian Baka hunter-gatherers were relatively low, which may enable them to adapt to low food availability in the village camps during the rainy season.

Key Words: Nutritional status; Anthropometry; Energy expenditure; Dietary intake; Food consumption; Pygmy; Cameroon.

INTRODUCTION

Pygmy hunter-gatherers in the tropical rain forest of central Africa have attracted the attention of anthropologists and human biologists for many decades because they are extremely short in stature. The stature of adult Pygmy hunter-gatherers have been measured and reported in several studies (Bailey, 1991). However, the nutritional status of these populations has rarely been studied (Dietz *et al*., 1989).

Discussions of the adaptive mechanisms of the small body size in Pygmy hunter-gatherers offer multiple scenarios for the observed patterns. Excluding genetic factors, three selective hypotheses have been proposed: 1) selection for thermoregulatory efficiency, 2) selection for low caloric needs, and 3) selection for reduced cost of mobility in the dense understory of the tropical rainforest (Shea & Bailey, 1996). Despite the importance of assessment of nutritional intake, quantitative nutritional surveys of Pygmy hunter-gatherers have been limited. There is a need for the measurement of daily energy expenditure to elucidate metabolic adaptation to ambient temperature and energy cost of mobility, as few studies on human energetics have been conducted in Pygmy hunter-gatherers.

In the 1980's, a team represented by Bailey & DeVore conducted numerous human biological studies, as well as socio-cultural anthropological and archaeological studies among the Efe hunter-gatherers and Lese horticulturists in Zaire. This project called the "Ituri Project" included broad areas of study fields such as demography, nutrition and growth, reproductive ecology, activities, food consumption, and ethnoarchaeology (Bailey & DeVore, 1989). However, no measurement of energy expenditure was performed. More recently, other groups (Koppert *et al.*, 1993; Pasquet & Koppert, 1993; Froment *et al.*, 1993; Garine, 1993) have conducted studies on human adaptability to tropical environments in the dense forest in the Campo region of southern Cameroon. Studies were performed amongst the Kola (Bakola) hunter-gatherers and their neighboring fishing population (Yassa) and agriculturist population (Mvae). This project, "Food Anthropology of Cameroonian Populations" incorporated nutritional and metabolic aspects, health aspects, ethnographic issues and ecological considerations. However, daily energy expenditure and daily physical activity patterns were studied in the two neighboring populations but not in the Pygmy hunter-gatherers. Furthermore, with respect to the Baka hunter-gatherers, the subject population of the present study, few studies have investigated human biology, with one notable exception being the study on blood pressure by Kesteloot *et al.* (1996).

The aim of the present study was to assess the nutritional adaptation of the adult population of Baka hunter-gatherers who had semi-settled in the village camps in southeast Cameroon. Anthropometric measurements were performed for the whole adult population in three village camps. In addition, we performed 24 hr heart rate monitoring, measurement of amount and composition of consumed food, and observation of the daily activity in two married couples (one young, the other older) over a period of three consecutive days. We report here the nutritional status as well as daily physical activity, energy and major nutrient intake, and total daily energy expenditure among Baka hunter-gatherers. Furthermore, we compared our results to those of previous studies of other groups of Pygmy hunter-gatherers.

MATERIALS AND METHODS

I. Study Populations

The Baka are one of the groups of so-called "Pygmies," dwelling in the tropical rainforests across the Central African Republic, Republic of Congo, and Cameroon. Their population is estimated between 30,000 and 40,000 (Althabe, 1965). Settlement of this population commenced in the 1950's and remains in progress today. The main subsistence activities are changing from hunting and gathering to horticulture. In the area where our studies are conducted, there are four seasons: the major rainy season (September to November), major dry season (December to March), minor rainy season (April to May), and minor dry season (June to August). The Baka move into the forest and stay at a hunting camp for two or three months during the major dry season (Tsuru, 1998). In the remaining periods of a year, they dwell in village camps close to the villages of neighbouring agriculturists. They perform horticulture exploiting the surrounding secondary forests in addition to hunting and gathering in the forest. They plant subsistence crops such as cassava, plantain banana, taro, okra, and maize. In addition, cacao cultivation as a cash crop was introduced recently. Details of the study area are provided elsewhere (Sato, 1998; Tsuru, 1998). The fieldwork was conducted from August to October 1996 in the village camps of the Baka in Ndongo, located 14˚50’ east longitude and 2˚10’ north latitude in the Moloundou Subdivision of the Boumba-Ngoko District, East Province of Republic of Cameroon.

II. Anthropometry

A total of 148 married males (n=75) and females (n=73) from three villages volunteered to participate in a study of anthropometric measurement in September 1996. Anthropometric dimensions were measured following standard protocol (Weiner & Lourie, 1981). Stature was measured to the nearest 1 mm using a field anthropometer (GPM, Switzerland), and weight was measured to the nearest 0.1 kg using a portable digital scale (Tanita model 1597, Japan). Upper arm circumference (UAC) was measured with a measuring tape. Skinfold-thickness was measured at the triceps and subscapular sites, to the nearest 0.2 mm, using skinfold calipers (Holtain, Briberian, UK). All anthropometric measurements were performed by the same investigator (TY). The two-site skinfold equation of Durnin & Womersley (1974) was used in combination with the equation of Siri (1956) to estimate body fat percentage (%fat). Body mass index (BMI; kg/m^2) was calculated as body weight (kg)/height $(m)^2$. Because most participants did not know their exact age, they were categorized into five age groups (below 20, 20-29, 30-39, 40-49, and over 50 years of age) according to a local assistant who was well educated, has lived in the nearby villages, and knew the participants well. Our sample included 15 married teenagers (6 males and 9 females).

III. Activity Observation, Energy Expenditure, and Food Consumption

From the above participants, we chose two married couples (aged 20s and 40s, respectively), for 24 h heart rate (HR) monitoring, observation of direct activity, and survey of food consumption during three consecutive days in September and October 1996. Using a cardiofrequency meter (Vantage XL, Polor Electro, Kempele, Finland), the HR of each participant was monitored for 24 hours from around 5:45 to the same time on the following day. The HR monitoring system consisted of an electrode-belt pulse transmitter and a wrist microcomputer receiver, which digitized and stored the recorded pulse. This system was light ($<$100 g) and did not disturb participant behavior. The pulse was recorded at 1minute interval. The maximum recording capacity of the system was 2,020 minutes. During the period of HR monitoring (excluding nighttime), each participant was monitored behaviorally by one of the authors (TY). The exact time of change of physical activity was recorded for each subject. Using this monitoring/recording protocol, it was possible to describe the HR value in relation to the physical activity throughout the daytime.

IV. Step Test

Measurement of HR during step tests and resting positions (sitting and standing) was also conducted in 49 adult males (n=24) and females (n=25), including the two couples monitored for HR and behavioral investigation. During the survey, each subject was requested to do two different step tests following the authors' instructions in Pidgin French and/or Baka language. The duration of each step test was 3 minutes and the height of the step was 0.3 m. Each subject stepped up and down at a constant pace of 15 and 30 times per minute, respectively. HR was monitored every 15 seconds. The HR value in the last 1 minute (i.e., average of four HRs per 15-sec.) was used for analysis.

V. Basal Metabolic Rate and Energy Costs during Step Test

Basal metabolic rate (BMR) was estimated by the equations of FAO/WHO/UNU (1985) based on the participant's body weight, gender and age group. The energy cost of each step test was calculated, based on the assumption that the net mechanical efficiency (NME) of each step test was equal to 16% (Yamauchi & Ohtsuka, 2000) using the following formula:

$$\text{NME (16\%)} = 100 \times \text{Work load (J/min)/Energy cost (J/min)}$$
$$= 100 \times \text{Wt} \times \text{Ht} \times 9.8 \times \text{N/(EE} - \text{BMR)},$$

where Wt=body weight (kg), Ht=height of steps (m), N=number of ascents/min, EE=energy expenditure of stepping (J/min) and BMR=basal metabolic rate (J/min).

VI. Total Daily Energy Expenditure Estimated by the Flex-HR Method

There is no standard procedure for determining the flex-HR point which discriminates between resting and exercise HR values (Panter-Brick *et al*. 1996). In this study, flex-HR was determined as the average of the mean HR measured at standing and the mean HR measured during the step test for 15 up and down repetitions. The recorded HR values were then converted to energetic equivalents using each participant's energy expenditure-HR regression line, to estimate total daily energy expenditure (TEE)(Spurr *et al.,* 1988; Ceesay *et al*., 1989). Energy expenditure (EE) during sleep was assumed to equal BMR (Goldberg *et al*., 1988). For HR values that were equal or below the flex HR point, 1.4×BMR was assumed to represent the energy cost at rest (Ceesay *et al*., 1989; FAO/WHO/UNU 1985). Values above the flex HR point were converted to energy costs, based on a regression line, which was calibrated for each participant. The TEE was then calculated using the following formula:

$$\text{TEE} = \sum(\text{sleeping EE}) + \sum(\text{sedentary EE}) + \sum(\text{active EE}).$$

The physical activity level (PAL=TEE/BMR) was also determined for each participant on each day. Further details on the procedure are provided elsewhere (Yamauchi *et al*., 2000a; 2000b; 2001).

VII. Dietary Intake

Dietary consumption was examined for each participant on the same day of HR monitoring. All foods consumed were weighed with a portable beam scale before and/or after cooking throughout the daytime period. In addition, the participants were asked in the morning about the types and amounts of foods consumed during the previous night. The energy, protein, and fat contents were estimated using African food composition tables (Leung, 1968).

VIII. Statistical Analysis

Gender differences in anthropometric dimensions were examined for statistical significance using the unpaired *t*-test. A P value $<$ 0.05 denoted the presence of a significant statistical difference.

RESULT

The age distribution and anthropometric characteristics of the participants are shown in Table 1. The age distribution was similar between males and females. Significant gender differences were found in all anthropometric indices except for BMI. Males were significantly heavier and taller than females ($P<0.0001$ for each index). Males also had a larger upper arm circumference (UAC, $P<0.005$), but smaller skinfold thickness (triceps and subscapular) and %fat than females (P<

Table 1. Age distribution and anthoropometric characteristics of the survey participants[1].

	Males n=75	Females n=73
Age group		
−20	6	9
20−30	33	31
30−40	18	19
40−50	14	11
50+	4	3
Weight (kg)	49.6±6.2	44.4±5.7*
Stature (cm)	154.4±6.0	146.6±4.8*
BMI[2] (kg/m2)	20.8±1.9	20.6±2.1
UAC[3] (cm)	25.9±1.9	24.8±2.2[#]
Triceps (mm)	5.8±1.6	10.1±3.6*
Subscapular (mm)	10.0±2.3	14.1±5.2*
Fat (%)	13.6±2.9	24.3±5.2*

[1] Data are mean±SD
[2] Body mass index.
[3] Upper arm circumference.
*P<0.0001.
[#] P<0.005.

Table 2. Mean standard deviation (SD) and coefficient of variation (CV) of time spent in categorized activities per day.

	Older Male		Younger Male		Older Female		Younger Female	
	Mean±SD (min)	CV (%)	Mean±SD (min)	CV (%)	Mean±SD (min)	CV (%)	Mean±SD (min)	CV (%)
Sleeping	519±30	6	502±39	8	490±69	14	329±64	20
Resting	730±37	5	721±107	15	729±89	12	747±165	22
Travelling	97±56	58	73±33	44	70±38	55	131±53	40
Working	21±23	113	86±149	173	43±37	87	81±129	159
Meal	52±6	12	40±12	30	57±12	20	59±9	16
Miscellaneous	21±12	58	18±14	77	50±25	50	93±42	45
Total	1440		1440		1440		1440	

0.0001 for each index).

Table 2 shows the mean duration of various daily activities of the two couples examined over a period of three consecutive days. The observed physical activities were classified into six different categories: sleeping, resting, traveling, working, meal, and miscellaneous (cf. Yamauchi *et al.*, 2000a). Resting consisted of three resting activities: lying, sitting, and standing. This category was the most dominant among six categorized activities, and the participants spent 70-80% of their waking hours in these sedentary activities. The intra-individual coefficient of variation (CV) for three days was relatively small (range, 5-22%). The second dominant category was sleeping. The females tended to sleep shorter than males, especially the younger female. As in resting, the intra-individual CV for the sleeping category was small (6-20%). Traveling included normal walking, as well as 'slow-paced' walking in and around the house or in the garden when the participants alternated standing with walking a few steps at a time (cf. Yamauchi *et al.*, 2000a). None of the participants was seen running during the daytime. The intra-individual CV in the traveling category was relatively large (40-58%) compared to those of Resting and Sleeping categories. The younger female spent about 40 min/day longer traveling than the others. Working denoted the net work time composed of two types of agricultural activities: 1) cleaning the bush and gathering food in the participants' own gardens, and 2) husking and collecting cacao fruits in the gardens of neighboring horticulturists (the Bakwele). Total working time, including time required for traveling to and from gardens and short periods for resting in gardens, as well as the net working time, were 35, 120, 58, and 129 min/day in the older male, younger male, older female, and younger female, respectively. Both intra- and inter-individual CV for the Working category were the largest of all categorized activities. The older couple spent considerably shorter time working, especially the older male, relative to the younger couple. The intra-individual CV for the working category exceeded 100% among three out of four participants. However, there was little gender difference in working time in both the younger and the older couple. The meal ctegory consisted of time spent preparing food, and eating. The couples ate three meals a day. The intra- and inter-individual CV for the meal category were small, as was the gender difference. The miscellaneous category included all activities that were not classified into above five categories. This time tended to be longer in females than males, and the intra-individual CV for this category was relatively large.

Table 3. Dietary energy, protein, and fat intake.

	Weight	Energy		Protein		Fat	
	(kg)	Mean±SD (MJ/d)	CV (%)	Mean±SD (g/d)	CV (%)	Mean±SD (g/d)	CV (%)
Older Male	42.3	6.9±1.1	16.0	47.1±24.7	52.4	6.6±2.4	35.7
Younger Male	48.1	7.5±1.5	20.5	73.2±40.4	55.3	10.4±7.3	70.2
Older Female	39.8	5.3±0.8	16.0	24.3±9.2	37.8	9.6±10.4	107.7
Younger Female	37.4	8.2±0.7	8.8	47.1±15.9	33.8	10.3±3.7	35.8

Table 4. Body weight, BMR, TEE, and PAL[1].

	Weight (kg)	BMR (MJ/d)	TEE[2] (MJ/d)	PAL[2]	CV (%)
Older Male	42.3	5.7	8.5±0.0	1.5±0.0	0.4
Younger Male	48.1	5.9	7.9±0.3	1.3±0.1	4.3
Older Female	39.8	4.9	7.3±0.7	1.5±0.2	10.1
Younger Female	37.4	4.4	7.2±1.3	1.7±0.3	18.2

[1] BMR: basal metabolic rate, TEE: total energy expenditure,
PAL: physical activity level (=TEE/BMR).
[2] Mean and SD.

Dietary energy, protein and fat intake for the two couples are shown in Table 3. The mean daily energy intake ranged between 5.3 MJ/d (1,260 kcal/day) in the older female and 8.2 MJ/day (1,952 kcal/day) in the younger female. The latter person was the lightest, but had the largest energy intake of all participants. The intra-individual CV of energy intake for three days ranged between 9% in the younger female and 21% in the younger male. In contrast, the CV of protein and fat intakes were larger than of energy intake (34-55% for protein intake, 36-108% for fat intake). The daily protein intake satisfied the daily safety level (FAO/WHO/UNU, 1985) for all participants except for the older female.

The BMR, TEE and PAL for the two couples are shown in Table 4. The younger female had the lowest average TEE. However, when it was standardized by BMR (i.e., in PAL), she had the highest PAL of all participants. In contrast, the younger male had the second highest TEE, but had the lowest PAL of all members of the group. The intra-individual CV of TEE or PAL ranged between 0 (0.4) and 18%, smaller than that of total energy intake (TEI)(Table 3). The inter-individual variation of TEE was also smaller than that of TEI. The mean PAL value of the young female corresponded to 'moderate-heavy' level, but 'light' for the others, according to the guidelines of FAO/WHO/UNU (1985).

The daily energy balance (TEI-TEE) as well as TEE and TEI for each participant are illustrated in Fig. 1 (males) and Fig. 2 (females). In general, the daily variation in TEI and TEE tended to be larger in females than in males. In addition, the variation in TEI was larger than that of TEE. The balance between TEI and TEE was negative in each sex. However, they were balanced, with the difference within 1 MJ (10%) in each sex.

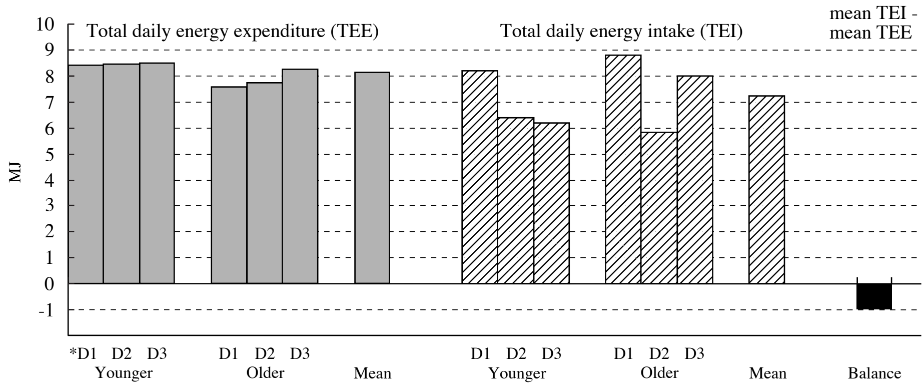

Fig. 1. Total daily energy expenditure (TEE), total energy intake (TEI), and energy balance (mean TEI-mean TEE) of the younger and the older Baka male measured over three days.
*D1, D2, D3 denotes day1, day2, day3, respectively.

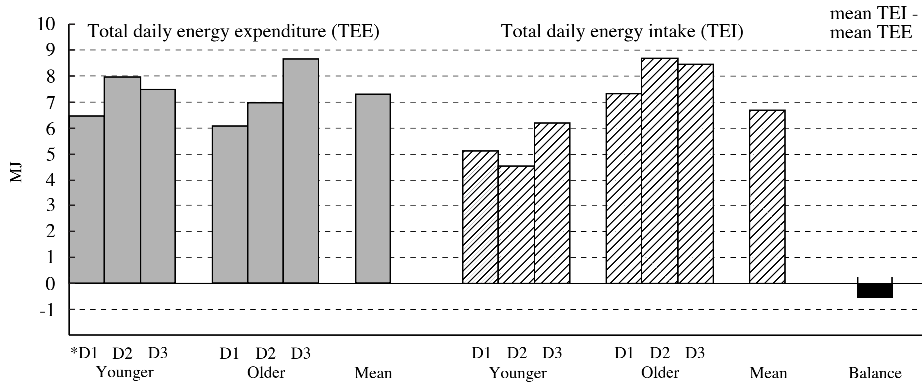

Fig. 2. Total daily energy expenditure (TEE), total energy intake (TEI), and energy balance (mean TEI-mean TEE) of the younger and the older Baka female measured over three days.
*D1, D2, D3 denotes day1, day2, day3, respectively.

DISUCUSSION

I. Nutritional Status of the Baka

The stature of the Baka is in the middle range among African Pygmy populations (Table 5). Among these groups, detailed anthropometric data are only available for the Efe (Dietz *et al*., 1989). Although the Baka is taller (by 10 cm) and heavier (by 5-6 kg) than the Efe, the smallest among the Pygmies, the BMI and %fat are similar between the two (BMI was 20.8 and 20.5 for Baka and Efe males, respectively, 20.7 and 21.3 for Baka and Efe females, respectively; %fat was 13.6 and 13.4 for Baka and Efe males, respectively, 24.3 and 25.0 for Baka and Efe females, respectivery). Furthermore, Dietz *et al*. (1989) reported that few clinical signs related to nutritional deficiency were observed in the Efe population. Although we did not perform clinical health examinations for the Baka to be compared with the results of Efe, we can

Table 5. Mean adult stature of African Pygmy populations.

Population	Mean stature (cm) Male	Female	Source
Efe (Ituri, Zaire)	143	136	Bailey 1991
Mbuti (Ituri, Zaire)	144	137	Cavalli-Sforza 1986
Baka (Cameroon)	151	144	Kesteloot *et al*. 1996
Aka (C.A.R.)	153	144	Pennetti et al. 1986
Twa (Kivu, Zaire)	153	n/a	Ghesquiere and Karvonen 1981
Baka (Cameroon)	154	147	Present study
Bakola (Cameroon)	160	n/a	Ferretti *et al*. 1991
Twa Pygmies (Ruanda)	160	n/a	Eveleth and Tanner 1976
Twa Pygmies (central Zaire)	n/a	150	Pagezy 1978

Table 6. Assessment of undernutrition and obesity from body mass index (BMI).

Categories	BMI	Males	Females
Obesity (grade-1)[1]	25−29.9	2 (2.7)*	3 (4.1)
Normal	18.5−24.9	66 (88.0)	59 (80.8)
CED[2]	<18.4	7 (9.3)	11 (15.1)
Total		75 (100.0)	73 (100.0)

[1] Accroding to a classification by Garrow (1981).
[2] Chronic energy deficiency (James *et al*., 1988).
*Numbers in parentheses represent percentage data..

reasonably conclude that such tests are unlikely to show clinical signs of nutritional deficiency.

The BMI in more than 80% of the participants in this study (88% in males, 81% in females) was within the normal range (18.5<BMI<25.0, Table 6). Based on the classification by Garrow (1981), five participants were categorized as 'obese' (grade1, BMI=25.0−29.9), although they were only slightly above the normal range (25.4 and 26.0 in males and 25.3, 25.3 and 25.6 in females). On the other hand, the BMI of 18 participants was below 18.5. In this regard, James *et al*. (1988) defined chronic energy deficiency (CED) as BMI<18.5 associated with PAL<1.4. In addition, the results of the daily energy expenditure survey showed that PAL was above 1.4 in three out of four participants who were monitored for energy expenditure. Therefore, it is likely that only a few participants would have both BMI<18.5 and PAL<1.4 and hence be classified as 'CED'. It was thus considered that the nutritional status of the Baka was of a normal level and that most of the participants were not undernourished.

II. Assesment of Daily Energy and Protein Intakes of the Baka

Our study of 24-h HR monitoring, observation of daily activity, and food consumption survey was conducted for only three consecutive days in two married couples at the village camps during the rainy season. Due to these limitations, we cannot say that the results of this study represent the general status of the Baka for all seasons (dry and rainy seasons) and two dwelling locations (i.e., village and forest camps). In spite of these limitations, we believe it is useful to compare our results on the Baka with those of previous studies on other Pygmy populations in

Table 7. Comparison of energy and protein intake[1] of Baka with Pygmies and other Cameroonian forest populations.

Population[2]	Energy		Total protein	Percentage of
	(MJ)	(kcal)	(g)	animal protein
Pygmies				
Baka[a)] (Cameroon)	7.0	1666	48	52
Bakola[b)] (Cameroon)	7.6	1816	56	78
Aka[3c)] (Congo)	7.9	1895	88	81
Other Cameroonian populations				
Yassa[b)]	7.6	1819	51	88
Mvae[b)]	7.7	1839	57	70
Douala[d)]	7.2	1719	55	57
Evodoula[d)]	6.8	1634	40	27
Batouri[d)]	6.8	1611	31	32

[1] Per capita.
[2] Sources: [a)]present study; [b)]Koppert *et al.*, 1993; [c)]Kitanishi, 1995; [d)]Périssé, 1966, Pondi *et al.*, 1991.
[3] Average of six measured periods.

order to understand the energetic adaptation of the Baka hunter-gatherers.

Both energy and protein intakes of the Baka were lower than those of other Pygmy hunter-gatherers previously studied, the Bakola and the Aka (Table 7). However, when compared to non-Pygmy Cameroonian populations, the energy and protein intakes of the Baka were comparable to those of the Douala and the Evodoula. On the other hand, a seasonal variation in energy and protein intakes due to differences in food availability has been reported among Pygmy hunter-gathers (Koppert *et al.*, 1993; Kitanishi, 1995), and neighboring fishing and/or agricultural populations in the Cameroon (Garine & Koppert, 1988). The daily energy intake of the Aka hunter-gatheres in Congo ranges between 4.0 (961 kcal/day) and 10.7 MJ/day (2,551 kcal/day) in six measured periods throughout the year (Kitanishi, 1995). In addition, the lowest energy intake throughout the year in Bakola pygmies in the Cameroon is recorded in the rainy season (November throghout December), measuring about 0.4 MJ/day lower than the annual average (Koppert *et al.*, 1993). This energy intake value for the Bakola in the rainy season was similar to the results for the Baka in the rainy season.

The present findings, together with those of previous studies on Pygmy hunter-gatherers indicate that our results on energy and protein intake in the Baka reflect the season of the lowest food availability throughout the year. Nevertheless, the energy intake was balanced with the energy expenditure, and the protein intake satisfied WHO standards of daily safety level.

III. Diet Balance of the Baka

In order to evaluate the diet balance of the Baka hunter-gatherers, food consumed by the participants was categorized into three groups: meat and fish, starch and cereals, and vegetables, fruits, and others. The respective proportions (%) of these three food groups relative to consumed weight (Fig. 3), energy intake (Fig. 4), and protein

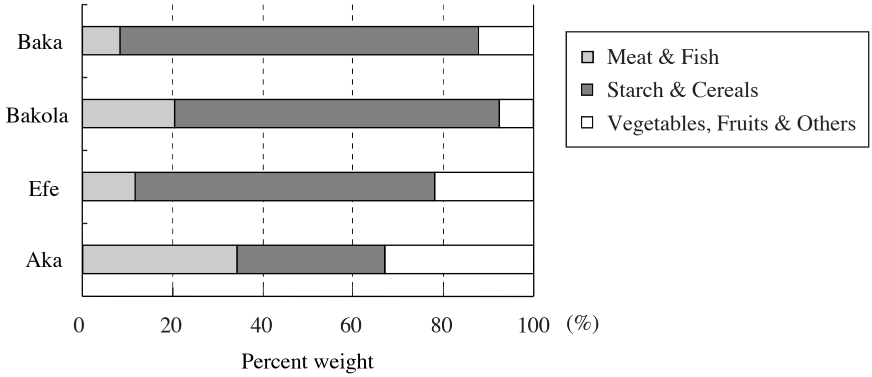

Fig. 3. Food composition expressed as percentage of the weight of consumed food.
Sources: Baka, present study; Bakola, Koppert *et al.* (1993); Efe, Bailey and Peacock (1988); Aka, Kitanishi (1995).

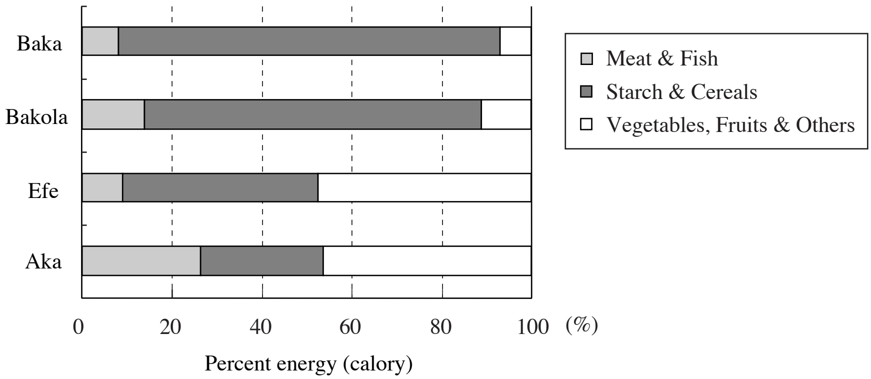

Fig. 4. Contribution of various food categories to the energy content of consumed food.
Sources: Baka, present study; Bakola, Koppert *et al.* (1993); Efe, Bailey and Peacock (1988); Aka, Kitanishi (1995).

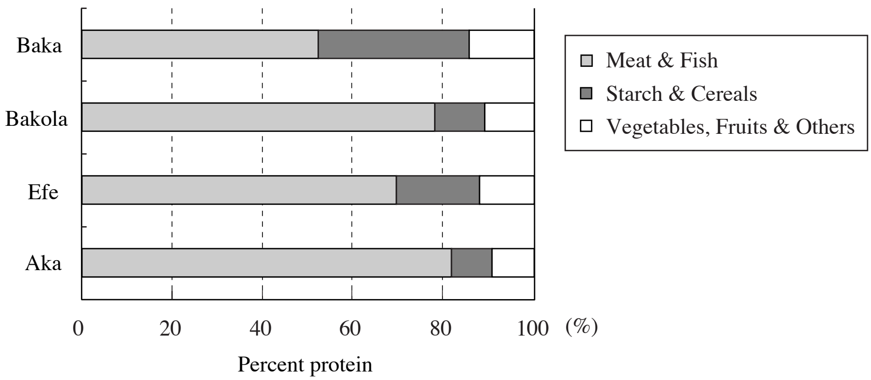

Fig. 5. Contribution of various food categories to the protein content of consumes food.
Sources: Baka, present study; Bakola, Koppert *et al.* (1993); Efe, Bailey and Peacock (1988); Aka, Kitanishi (1995).

intake (Fig. 5) were calculated and then compared to previous studies for other Pygmy hunter-gatherers (i.e., the Bakola, Efe, and Aka).

Firstly, starch and cereals constituted 80% of total food weight consumed by the Baka, and 65-75% of that by the Bakola and Efe. However, in the Aka, the total food weight consumed was evenly divided between the three food groups (Fig. 3). Secondly, the results of energy intake studies were similar to those of the food weight studies (Fig. 4), and starch and cereals was dominant (85%) for the Baka. Similarly, starch and cereals constituted 75% of the food consumed by the Bakola, although this type of food represented a lower proportion among the Efe and Aka food consumption. In contrast, vegetables, fruits, and others formed a large percentage of food consumed by these two populations (48% in Efe, 46% in Aka, compared to 11% in Bakola, 7% in Baka). This is probably due to the large intake of wild seeds, palm fruits, and honey (Bailey & Peacock, 1988; Kitanishi, 1995). Lastly, meat and fish were the main source of proteins, making up over 50% for the Baka (Fig. 5). However, the contribution of meat and fish to protein intake was significantly higher among the other three populations (70-80%). The Baka depended largely on starch and cereals, especially plantain banana (38% of total energy intake) for energy, and when compared to other Pygmy hunter-gatherers, the proportion of meat and fish to protein intake was low. This may be associated with a low consumption of meat and fish, and the consequent relatively low intake of protein (Table 7). These findings indicate that food availability, especially of meat and fish, is low at village camps in the rainy season. In addition, it is possible that food availability is higher at forest camps and/or in the dry season.

IV. Daily Physical Activity Level of the Baka

Similar to the results of this study regarding nutritional intake, the results of total daily energy expenditure (TEE) and physical activity level (PAL) do not take annual cycles into account. Nevertheless, it is still worth comparing our results to those for African subsistence-level populations, since, to our knowledge, there is no study that have measured TEE in Pygmy hunter-gatherers, although several studies on human energetics have been conducted in other African populations (Table 8).

PAL was markedly low in the Baka males compared to other African subsistence-level populations (Table 8). Thus, PAL of the Baka males was lower than either hunter-gathers (!Kung) or Cameroon agricultural/fishing populations (the Massa, Yassa, and Mvae). On the other hand, PAL of the Baka females was somewhat intermediate among African populations, and was similar to that of the hunter-gather !Kung, but lower than those of other Cameroonians.

Two possible reasons might explain the significantly low PAL of the Baka compared to other African populations. One is that the participants in this study spent 80% of their waking hours (approximately 12 hours/day) in 'resting' activities (i.e., lying, sitting, and standing), and were considered very sedentary during the survey period. The other is that they spent only a few hours each day performing energy-demanding activities such as 'travelling' and 'working,' The sum of the time spent in these two categories ranged from 113 (old female) to 212 (young female) min/day. Because African Pygmies lead a hunter-gatherer's life, their habitual physi-

Table 8. Daily physical activity levels of African populations

Country	Subsistence type	PAL[1]	Reference
Males			
Gambia	Rice and peanut cultivation	2.02*	Fox 1953
Burkina Faso (Upper Volta)	Millet cultivation	1.89*	Brun *et al*. 1981
Cameroon (Massa)	Millet cultivation, fishing	1.87	Pasquet *et al*. 1992
Cameroon (Yassa)	Millet cultivation, fishing	1.71	Pasquet and Koppert 1993
Botswana (!Kung)	Hunter-gatherer	1.71	Lee 1979
Ivory Coast	Mixed cultivation	1.68	Dasgupta 1977
Uganda	Maize and plantain cultivation	1.63	Cleave 1970
Cameroon (Mvae)	Millet cultivation, hunting	1.60	Pasquet and Koppert 1993
Cameroon (Baka)	Hunter-gatherer	1.41	Present study
Kenya (Turkana)	Pastoralists	1.29	Galvin 1985
Females			
Gambia	Rural farmers	1.97	Singh et al. 1989
Burkina Faso (Upper Volta)	Millet cultivation	1.80	Bleiberg *et al*. 1980
Gambia	Rural farmers	1.74	Heini *et al*. 1991
Cameroon (Mvae)	Millet cultivation, hunting	1.72	Pasquet and Koppert 1993
Cameroon (Yassa)	Millet cultivation, fishing	1.67	Pasquet and Koppert 1993
Cameroon (Baka)	Hunter-gatherer	1.56	Present study
Botswana (!Kung)	Hunter-gatherer	1.51	Lee 1979
Ethiopia	Cultivation	1.47	Ferro-Luzzi *et al*. 1990
Kenya (Turkana)	Pastoralists	1.37	Galvin 1985
Swaziland (Swazi)	Cultivation	1.35	Huss-Ashmore *et al*. 1989

[1] Physical activity level (=TEE/BMR).
*Average of two seasons.

cal activity seems to be considerable (Ghesquiere & Karvonen, 1981). However, the Baka pygmies in this study were not so active as expected. It must be noted that hunting-related activities were rarely observed among the participants during the survey periods. The only such activity observed was when a young male checked some traps for 18 min while he travelled from one village to another. Since there is only limited information on TEE or PAL for the Baka hunter-gatherers, further discussion is not possible until data that takes seasonality and dwelling places into account becomes available.

In conclusion, we have reported in this field study that the stature of the adult Baka hunter-gatherers in southeast Cameroon was intermediate among other Pygmy hunter-gatherers, and they were not undernourished. Due to the limited sample size and survey duration, it is not possible to conclude that the results of this study present the average throughout the annual cycle. However, our analysis showed that the energy intake and energy expenditure are both low in Baka hunter-gatherers, which allows them to adapt to low food availability in the village camps during the rainy season. In addition to the low energy intake, the protein intake was relatively low in Baka hunter-gatherers compared to other Pygmy hunter-gatherers, though it satisfied WHO standards for daily safety levels. A long-term field survey study which takes into account such factors as seasonality (dry and rainy seasons) and dwelling location (village versus forest camps) is needed to determine the nutritional adaptation among Baka hunter-gatherers. In addition, few studies on human energetics have been conducted in Pygmy populations. These studies are essential to test the hypotheses that the Pygmy's small body size is due to various factors related to the individuals and surrounding environment, such as metabolic adaptation to low food availability and ambient temperature, as well as allowing increased mobility in the forest. Therefore, there is an urgent need for studies measuring BMR as well as TEE in Pygmy hunter-gatherers.

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