CHAPTER 25

ACTIVITY PATTERNS AND ENERGY EXPENDITURE IN CAMEROONIAN TROPICAL FOREST POPULATIONS

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INTRODUCTION

Physical activity is the main component of energy expenditure in subsistence societies, notably in the African rain forest. Activity patterns are socially determined. They are the place of integration of most behavioural responses to scarcity (Ferro-Luzzi, 1988) or to the increase of nutritional needs such as, for instance, seasonal availability of food or the increase of biological needs related to reproduction.

Comprehensive data on activity patterns and energy expenditure are fragmentary for the humid tropics, and especially in African rain forest populations. Numerous field studies focused on anthropological, ecological or developmental issues have contributed to our knowledge of gross patterns of activity and work load, using time allocation techniques (Gross, 1984). Very few studies, however, have reported accurate estimates of both time expenditure and activity metabolic rates which are needed for a good understanding of human nutritional requirements, although one can cite the energy balance studies conducted by Montgomery and Johnson (1977) among the Machiguenga horticulturalists of Peru and by Dufour (1984, 1992) among the Tukanoan Indians of Colombia.

The purpose of this contribution is (1) to describe patterns of activity and habitual energy expenditure in two Cameroonian rain forest communities living at the level of subsistence – the fishermen-agriculturalist Yassa and the hunter-agriculturalist Mvae; (2) to compare these findings with estimates in other Cameroonian forest populations who have adopted a different strategy of production: cacao planters; and (3) to compare the estimates of energy expenditure to the worldwide variation.

The ecological setting of the studied populations is presented by Koppert *et al.* (1993, this volume), with data on food consumption; their health status and socio-cultural background are also discussed, respectively by Froment *et al.* (1993, this volume) and by Garine (1993, this volume).

METHODOLOGY

Field research was conducted from July 1984 to March 1986. The 'factorial method' (Passmore and Durnin, 1955) was used to assess habitual activity patterns and daily energy expenditure. This method calls for both observations of time allocation and measurements of the energetic cost of activities.

The time allocation survey was conducted by local assistants who recorded minute-by-minute activities, postures, loads carried and pace, on a sample of 87 subjects (26 Yassa men and 18 Mvae men, 22 Yassa women and 21 Mvae women). This was done for individual subjects in three seasons: rainy season, major dry season and minor dry season, during the portion of the day spent awake, over seven consecutive days in women and three days (including Sunday) in men. In order to obtain suitable seasonal comparisons, pregnant and early lactating women (under 6 months) were excluded from the study sample.

Table 25.1 Age and physical characteristics (mean ± SD) of Yassa and Mvae subjects participating in the measurement sessions

	Women (n=59)	Men (n=79)
Age (yr)	44.7 ± 12.0	38.5 ± 13.1
Height (cm)	156.2 ± 5.3	164.2 ± 6.4
Body weight (kg)	54.1 ± 8.1	60.3 ± 7.2
Body fat (%)[a]	27.1 ± 6.3	14.5 ± 3.4
Body mass index (Weight Height^{-2})	22.1 ± 3.0	22.3 ± 1.8

[a] From sum of four skinfolds, according to Durnin and Womersley, 1974

A sample of adults of both sexes in each population, from households chosen by drawing lots, was involved in the study of metabolic rates, all subjects having been fully informed of our aims and procedures. Their physical characteristics are shown in Table 25.1.

Metabolic rates were measured by indirect calorimetry for the most important subsistence activities in each community. Exhaled gases were collected using a mouth-piece connected to a 150 litre polyvinyl Douglas bag and the volume and concentrations of oxygen and carbon dioxide were measured using portable paramagnetic oxygen analyzers. The energy cost of individual activities per minute, calculated according to the formula of Durnin and Passmore (1967) – but using an equivalent of 20.6 kJ litre^{-1} of consumed O_2 in non fasting subjects – was expressed as a multiple of basal metabolic expenditure (estimated in each subject from weight, height and age, using the tables of Schofield, 1985): the so-called 'physical activity ratios' (PAR). For the unmeasured observed activities, reference was made to energy expenditure tables (expressed as PAR) including data from the literature (Passmore and Durnin, 1955; FAO/WHO/UNU, 1985; James and Schofield, 1990).

RESULTS AND DISCUSSION

Energy cost of the main activities

Table 25.2 presents the energy cost values for the main current activities for each sex among the Yassa and the Mvae. In both sexes, mean standardized lying metabolic rates did not differ statistically from basal metabolic rate (BMR) values predicted from Schofield's (1985) tables. The PAR of the various subsistence activities ranged from 1.77 times BMR to 3.90 in women and from 1.86 times BMR to 4.77 in men. According to the grading system given by James and Schofield (1990), most of the women's activities are classified as light or moderate work while many men's activities have to be classified as heavy work (PAR greater than four times BMR).

Table 25.2 Energy expenditure (mean ± SD) and physical activity ratios (PAR) for various representative activities among the Yassa and the Mvae

Activity[a]	Number of subjects	Women		Men	
		kJ min^{-1}	PAR	kJ min^{-1}	PAR
Lying at rest (standardized)[b]	53	3.83 ± 0.55	1.02		
	68			4.60 ± 0.63	1.00
Sitting at rest	55	4.35 ± 0.71	1.16		
	52			5.29 ± 0.84	1.16
Standing at rest	34	4.47 ± 0.72	1.20		
	42			5.76 ± 0.90	1.26
Walking (usual pace)	18	9.68 ± 1.26	2.60		
	17			11.73 ± 1.30	2.62
Walking (with 30 kg load)	19	13.14 ± 2.04	3.56		
Weeding	16	14.26 ± 2.73	3.90		
Bush clearing	19			19.59 ± 3.28	4.36
Chopping wood with machette	13	13.01 ± 2.53	3.52		
Planting manioc	11	13.90 ± 2.32	3.81		
Hoeing manioc	18	13.94 ± 1.98	3.78		
Harvesting manioc	11	12.65 ± 2.66	3.51		
Pounding manioc	26	9.46 ± 1.28	2.57		
Peeling manioc	8	6.77 ± 1.02	1.86		
Sieving manioc	11	8.10 ± 1.37	2.19		
Packing the "bâtons de manioc"	6	6.43 ± 1.30	1.77		
Paddling canoe (low intensity)	9			14.73 ± 2.50	3.32
Paddling canoe (high intensity)	15			19.64 ± 2.68	4.30
Fishing (setting down the net)	7			11.46 ± 3.11	2.53
Fishing (pulling up the net)	14			16.09 ± 2.41	3.54
Fishing tackle maintainance	7			8.22 ± 0.88	1.86
Building a canoe from a tree	10			21.50 ± 3.20	4.77

[a] At least two measurement sessions for lying, sitting, standing, and walking

[b] Immobility in the subject's house, after an 11–12 hours overnight fast, at 25–29°C

Seasonal patterns of activity and daily energy expenditure

Table 25.3 depicts the seasonality of total daily energy expenditure (TDEE), activity level and pattern on work days (excluding Sundays) among the Yassa and the Mvae. Activity was divided into nine main categories. Sleeping refers to both night and day sleep periods. Periods of time spent at rest, moving or travelling, were included in time allocated to the related main

Table 25.3 Total daily (work days) energy expenditure (TDEE), physical activity level (PAL) and daily time (min) allocated to the main activities, at different seasons, among the Yassa and the Mvae

	Women				Men			
	Minor dry season (Jul-Aug)	Rainy season (Nov-Dec)	Major dry season (Mar-Apr)		Minor dry season (Jul-Aug)	Rainy season (Nov-Dec)	Major dry season (Mar-Apr)	
YASSA								
Number of subjects	13	19	14		15	15	10	
Sleeping	623	596	598		557	485	504	
Education/child care	6	21	13		8	11	12	
Household activities	509	449	427	*	23	50	60	
Building	0	0	0		180	4	20	***
Agriculture	73	80	142	***	39	42	64	
Fishing	8	28	18		123	246	193	**
Hunting-trapping	0	0	0		29	27	2	
Individual needs	167	203	185		300	327	347	
Social activities	54	63	57		181	248	238	
PAL [BMR factor] [a]	1.65±0.09	1.71±0.11	1.73±0.10		1.74±0.20	1.72±0.21	1.73±0.19	
TDEE [MJ] [a]	8.82±0.61	8.99±0.81	9.17±0.88		11.67±1.89	11.44±1.54	11.41±1.61	
MVAE								
Number of subjects	16	16	17				14	
Sleeping	642	646	595	*			633	
Education/child care	5	18	15				15	
Household activities	375	334	273	**			63	
Building	0	1	0				10	
Agriculture	197	91	250	***			148	
Fishing	14	63	23				18	
Hunting-trapping	12	2	25				66	
Individual needs	158	215	207				399	
Social activities	36	70	52				88	
PAL [BMR factor] [a]	1.74±0.09	1.70±0.09	1.81±0.09	**			1.62±0.19	
TDEE [MJ] [a]	9.38±0.66	9.14±0.62	9.58±0.76				10.01±1.38	

[a] mean ± SD

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$, ANOVA

category of activity. Household activities consisted of housework tasks, food processing, cooking and distribution, and handicraft. Agriculture meant farming (bush clearing, cultivation, harvesting, breeding) and gathering. Fishing included fishing *per se*, fish processing and tackle maintainance. In individual needs were included eating, drinking, bodily needs and care, and any discretionary activity of an individual nature (i.e. non-work time minus time devoted to eating, hygiene, market and commercial activities). Social activities consisted of time devoted to market and commercial activities, religious activities, visiting friends or to any other discretionary activity of a social nature.

No seasonal variations were observed in the level of physical activity and daily energy output between fishermen Yassa, men and women. However, time devoted to agriculture by Yassa women was significantly longer during the dry season observation period (manioc planting time) at the expense of household tasks. Among the men, fishing was reduced during the minor dry season (bad sea conditions, long distance fishing practised by a minority of fishermen), liberating time for building.

By contrast, Mvae women showed seasonal differences in both activity level and activity patterns. Mean PAL was significantly higher during the major dry season while the time devoted to agricultural tasks was significantly reduced during the rainy season.

However, total daily energy expenditure (TDEE) remained unchanged from one seasonal observation period to the other. This was due to significant activity-related seasonal differences in body weight among the Mvae (see Froment *et al.*, 1993, this volume) and the use of this variable in the prediction of BMR and therefore the estimation of total energy expenditure.

As far as Mvae men are concerned, substantial data were available only for the dry season. Observations made on three subjects during two hunting days in the minor dry season gave the figure of 1.9±0.2 times BMR for physical activity level (PAL), suggesting some seasonal variation of activity level in Mvae men. However, the subjects were not the same as those observed during dry season.

Sexual division of labour

In addition to childcare and household tasks, most of the time devoted to routine agricultural activities fell to women, whereas men were mainly involved in foraging activities and seasonal agricultural tasks such as clearing of gardens and fields (among the Yassa and Mvae) and planting (only among the Mvae). Time allocated to productive labour followed different patterns according to gender and population. Indeed, some 27% of the waking day, i.e. 260 min day^{-1} (SD = 180) and 18.8% of the waking day, i.e. 116 min

day^{-1} (SD = 59) were taken up by agriculture plus fishing and/or hunting among Yassa men and women respectively. This difference is statistically significant ($t = 5.05$; $p<0.001$).

Among the Mvae, the time devoted to production represented 228 (SD = 99) min day^{-1} (28.3% of waking day) in women on a yearly basis. During the dry season observation period – for which data were available for both sexes – production took up some 316 (SD = 56) min day^{-1} (i.e. 38% of the waking day) and 212 (SD = 102) min day^{-1} (i.e. 26% of waking day) in Mvae women and men respectively (Mann Withney test: $z = 2.16$; $p<0.05$).

However, it should be noted that some 377 min day^{-1} (i.e. 52% of waking day) were taken up by productive labour in the three Mvae men observed during hunting days, of which 247 min were devoted to hunting.

The Mvae women spent more time in agriculture than did Yassa women ($t = 4.81$; $p<0.001$). This was due both to local conditions (greater distances travelling to the gardens) and to a strategy of staple diversification among the Mvae (mixed cultivation of macabo, plantain, taro, in addition to the manioc, almost the only Yassa crop) that requires increased field maintainance.

In both populations, women devoted a significant part of their working time to food processing, especially in making the pudding sticks of manioc (*chicuangue*), particularly the Yassa women (98 min day^{-1}, i.e. 16% of waking day).

No statistical difference was noted when comparing the mean (men + women) value of productive time between the Yassa and the Mvae during the dry season.

Difference between the sexes was found to be particularly important in terms of work vs leisure patterns in both populations. Indeed, in men, non-work time (summing the time spent for individual needs and social activities) was found to take up as much as twice that observed in women in both groups (on average 59% of waking time in men vs 28% in women). This difference is maintained (53% vs 23%) even when considering only discretionary activities (i.e. non-work time minus time devoted to eating, hygiene, market and commercial activities).

Comparison with other groups

The women's rates of energy expenditure for activities related to the acquisition of food – such as manioc planting, weeding or harvesting – were very similar to those reported for other rain forest populations living at the level of subsistence and relying on manioc as the main staple such as the Tukanoans (Dufour, 1984) and the Machiguenga (Montgomery and Johnson, 1977). In contrast, manioc processing activities among the Yassa

and the Mvae seemed to be performed at a lower rate, and in men, much lower expenditures were observed for self-pace walking and for the various horticultural tasks compared to Machiguenga men.

An overall pattern of sexual division of labour has been observed for groups of forest swidden agriculturalists (Dufour, 1984; Beckerman, 1987). The Yassa and the Mvae generally follow this pattern, but the Machiguenga, who live in a particularly constraining ecological setting, show a different behaviour in the time allocated to the acquisition of food. Men carried out intensively most of the horticultural work and foraging activities during 35% of daylight time, whereas women spent only 13% of daylight time on these tasks at a lower pace (Johnson, 1975).

One change among forest subsistence agriculturalists is the entry into cash cropping. This is particularly important in Cameroon where it is related both to the reduction of cultivable area following the expansion of roadside settlements, and to monetarization. Data on patterns and levels of activity have been compared with studies of other Cameroonian groups, especially an energy balance survey among the Eton women who grow manioc as staple and cacao for cash, carried out using the same methodology as in our study, in a periurban forest population (Pondi Njiki *et al.*, 1989). Compared to our results, the Eton showed significantly higher activity levels and daily energy expenditure (Figure 25.1). The time devoted to productive activities (almost entirely agriculture) was significantly higher, whereas household work and discretionary activities were reduced ($\chi^2 = 60.5$; $p<0.001$).

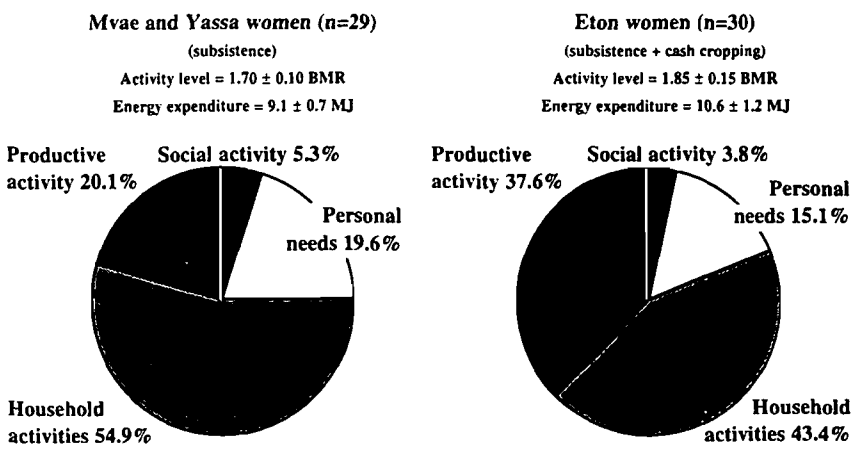

Figure 25.1 Activity patterns (on weekdays, during minor dry season) of rain forest populations with different lifestyles, showing significant differences in both physical activity level and total daily energy expenditure ($p<0.001$)

Moreover, Leplaideur (1978), in his time-and-motion study among cacao planters from central-southern Cameroon, has shown that the sexual division of labour followed the usual pattern, with men mainly involved in cash cropping (which accounts for two-thirds of the time spent on agricultural work) and women intensively growing staple food. The duration of agriculture-related tasks (on a yearly basis 5.6 hr day^{-1} in women and 4.6 hr day^{-1} in men) was substantially longer than that reported in the present study, especially for women (3.8 hr day^{-1} and 2.0 hr day^{-1} allocated, on average, by women to all subsistence work, among Mvae and Yassa respectively). This is also consistent with observations reported elsewhere, for example among the Shipibo of eastern Peru (Behrens, 1989) where changes in land use have coincided with greater labour time being devoted to rice production.

Table 25.4 Habitual daily energy expenditure (EE) and physical activity levels (PAL, expressed as BMR factors) in studies from populations living at subsistence level in various ecological settings

	Women		Men		
	EE	PAL	EE	PAL	References
Rain forest populations:					
Yassa (Cameroon)	8.87	1.67	11.41	1.71	Present study
Mvae (Cameroon)	9.21	1.72			Present study
" " dry season			9.90	1.60	Present study
Machiguenga (Peru)	8.05	1.72	13.40	2.11	Montgomery and Johnson, 1977
Tukanoans (Colombia)	8.92	1.71	12.05		Dufour, 1984, 1992
Other populations:					
Lufa (New Guinea)	9.40	1.82	10.75	1.64	Norgan *et al.*, 1974
Kaul (New Guinea)	7.65	1.57	9.82	1.56	Norgan *et al.*, 1974
Rural Savaii (Western Samoa)	9.50	1.60	12.16	1.60	Pearson, 1990
Upper Volta, rainy season	11.12	2.14	14.50	2.23	Brun *et al.*, 1979; Bleiberg *et al.*,1980
" " dry season	8.93	1.71	10.10	1.55	Brun *et al.*, 1979; Bleiberg *et al.*,1980
" " end harvest	8.10	1.54			Bleiberg *et al.*, 1981
Rural Guatemala	8.20	1.62			Schutz *et al.*, 1980
Southern India	8.23	1.53	9.56	1.56	Edmundson and Edmundson, 1988
Ethiopia	7.94	1.47			Ferro Luzzi *et al.*, 1990
Igloolik eskimo hunters (Canada)	9.87	1.79	12.61	1.82	Shephard, 1974
" " hunting days			13.35	2.22	Shephard, 1974

Not many energy expenditure investigations have been carried out on populations in rain forest areas (Table 25.4). Nevertheless, the activity level of the Yassa and Mvae in our study was within the range of that reported in other forest and non-forest subsistence populations (especially in women; men showing more variable patterns). Higher levels were found in intensive agricultural systems such as sugarcane plantations in Philippines and rice farms in Iran and Burma (de Guzman *et al.*, 1974; Brun *et al.*, 1979,1981; Tin-May-Than and Ba-Aye, 1985).

Finally, it should be noted that the seasonal variation of activity in the forest groups studied was not as marked as that reported elsewhere, notably variation from 10 to 14.5 MJ for men in Upper Volta, 12 to 13 MJ in rural Burma, or 11 to 13.6 MJ among Iranian agricultural workers (Bleiberg *et al.*, 1980, 1981; Tin-May-Than and Ba-Aye, 1985; Brun *et al.*, 1979).

CONCLUSION

The data reported in this paper represent a random sample of time and energy expenditure based on indirect calorimetry of African subsistence forest agriculturalists, for whom information was previously scarce.

There is widespread interest in the observation of activity patterns and the measurement of energy expenditure as they relate to the study of nutritional adaptability and the estimation of dietary energy requirements. The study demonstrates that the activity of the two Cameroonian populations investigated fell between the categories of 'light' and 'moderate' for men, 'moderate' and 'heavy' for women, according to the classification given by FAO/WHO/UNU (1985).

Moreover, the daily energy expenditure of these groups was within the range of that reported in other subsistence groups, especially for women. Greater activity levels were observed in groups where changes in land use such as cash cropping have occurred. Seasonal variations in activity, if any, were not very important compared with those observed elsewhere, for example in Sahelian populations.

ACKNOWLEDGMENTS

We wish to express our appreciation to the Institute of Human Sciences of the Ministry of Higher Education and Computer Sciences and Scientific Research of the Republic of Cameroon, for making this study possible.

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Pasquet P., Koppert Georgius (1993)

Activity patterns and energy expenditure in Cameroonian tropical forest populations

In : Hladik C.M. (ed.), Hladik A. (ed.), Linares O.F. (ed.), Pagezy H. (ed.), Semple A. (ed.), Hadley M. (ed.) Tropical forests, people and food : biocultural interactions and applications to development

Paris : UNESCO, (13), 311-320. (Man and Biophere Series ; 13)

Tropical Forests, People and Food : International Symposium, Paris (FRA)