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# Field Studies of Energy Expenditure - Logistics and Contributions

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## Introduction

The subject of this paper is the measurement of energy expenditure and energy balance under field conditions. The objectives of such work are to describe the health status of a community, to understand the regulation of energy balance, and to answer questions on human variation and adaptation in an ecological context. In part 1, I explain some of the steps taken in the choice and implementation of a protocole, and in part 2, I discuss the aims and validity of such field research. My talk draws largely upon one year's field experience in 1982-83 in the middle hills of central Nepal (village of Salme, district of Nuwakot). It was a study on the energetics of two population groups, the Tamang/Ghale, subsistence agriculturalists and herders, of Tibeto-Burmese origin, and the Kami, a blacksmith caste of Indo-Nepalese descent; more particularly, it focused on women, especially pregnant and lactating mothers. The project was integrated in the team research of the French National Centre of Scientific Research (G.R.E.C.O., Himalaya-Karakorum), which investigated in a multidisciplinary framework the relationships between man and his environment on this large Himalayan watershed.

## I

## CHOICE OF METHODOLOGY AND IMPLEMENTATION

### Measuring energy expenditure

Excellent reviews of the technical and analytical aspects of the measurement of energy expenditure are available in the literature (Durnin and Brockway, 1959; Durnin and Passmore, 1967; Durnin, 1978; Nelms, 1982). Only some practical steps taken in the field are described here. The procedure for measuring energy expenditure is not overly complicated, and consists in analysing samples of expired air during the exercise of a given activity. The subject is asked to perform the work wearing a noseclip and breathing through a mouthpiece which enables the collection of all expired air in a sample bag. The work is timed representatively and the total volume of respiration measured. The sample air is then analysed for its gas content, principally oxygen. From De Weir's formula (1949), which expresses a relationship between recorded volume, sample time and percentage of oxygen concentration, the oxygen uptake (VO2) is readily calculated in Kilojoule or Kilocalorie per minute. The value, corrected for body weight and body fat, is an estimate of the energy cost of the particular activity sampled.

A number of instruments designed for gas sampling may be taken to the field. The most recently developed are the Oxylog (Humphrey and Wolf) and the Miser (Eley et al). For my field purposes in Nepal, I chose the Kofranyi & Michaelis (Max Planck) respirometer, most widely used and of proven robustness in the longterm and isolated field conditions. It is a compact box, carried on the back (or front) of the subject, which meters the volume of expired air and samples it for subsequent analysis. A full bladder or plastic bag can be filled in an experiment lasting about 20-30 minutes. I also took a Douglas bag, which collects all the expired air and therefore cuts down the time of measurement to 3-10 minutes; this makes it more expedient to measure the cost of resting metabolism and the effort of a steptest. Next, for the purposes of gas analysis, I bought a portable battery-operated (Servomex) Oxygen Analyser, adjusted to local altitudinal pressures, and remarkable in convenience and precision. It needed however to be calibrated in the field with nitrogen (of 99.9% purity), shipped from British Oxygen Company, London. To calibrate the respirometers, I chose a three liter steel syringe (Cranlea Medical Electronics) to operate manually, since the dry-flow gas meter suggested by Durnin and Brockway (1959) is heavy and runs on electricity. Finally I included a heart-rate pulsemeter to monitor work effort; the relationship between heart rate and metabolic cost is not fully satisfactory (Bradfield 1971; Verma et al, 1979), but is useful information in the steptest. In short, necessary equipment, even kept to essentials, is quite cumbersome; mine was sent to Nepal, then carried two days to the village of fieldwork by proters. Equipment is also expensive (four respirometers were on loan; the oxygen analyser, the Douglas apparatus, the steel pump, the nitrogen cylinder, the pulsemeter cost £770, £75, £255, £180, £70 respectively).

The above measurements are made in order to describe the energy expenditure and the work efficiency of individuals in a community. This necessitates an appreciable number of measurements: they must be carried out on a range of tasks, concern a large sample of people, and repeated on the same subjects in order to properly ascertain inter and intra-individual variability. It is of course unecessary and unrealistic to want to measure all the activities undertaken in a community. Once in the field, one must first recognise the pattern of daily work in terms of single tasks, then select some for measurement. Minor activities, defined and described with proper care, can be looked up in tables of energy expenditure (Passmore and Durnin, 1955), based on other population groups. But those important in frequency and/or heavy in energy effort merit quantitative measurement: these are activities which the population under study might be expected to perform with improved efficiency, revealing adaptations to prevailing circumstances; these adaptations could be achieved through physique developed in growth and adolescence, or through adjustments in working behaviour. Thus the real interest in measuring energy expenditure in the field is to provide evidence for adaptive changes, rather than merely estimate the level of energy expenditure in the community. The variability displayed by individuals in performing the same task is also well worth considering, often revealing a remarkable range in work efficiency (Edmunson, 1979) which is yet to be fully understood.

Thus in estimating energy expenditure in the Nepalese community, I identified 135 single activities. I took care to distinguish walking on paths of different gradients, and carrying loads of different weights. These activities are both strenuous and frequent throughout the day. They are performed by people of short stature and light weight, a physique which might play a part in reducing the energy cost of carrying loads. Behaviour is also characteristic: the Nepalese carry loads in baskets ("doko") supported on their backs with a head-band, and punctuate their travelling to allow 5-10 minutes rest every half-hour or so; indeed they respect the resting places "bisan") erected regularly along the paths. In addition to walking and carrying, I measured the energy cost of resting, digging fields, ploughing, pounding cereals, and working metals. I took the equipment to where people were engaging in these activities, asking them to wear the respirometer and work as they would under normal conditions. A steptest was also included to measure standardised work performance. I worked with men and women between 15 and 50 years of age, with pregnant and lactating mothers and their non-childbearing counterparts. Five to twenty individuals of each category participated in the measurement of each activity (to total 345 measurements on eight defined activities). Intra-individual variability was fully measured only in the case of resting metabolism, due to the difficulties in effecting the measurements.

## Problems of Implementation in the Field

Indeed it proved a problem to elicit the cooperation of the population. These people, previously left to their ways, understood little of the reason for the presence of foreigners in the village. Not unsurprisingly, the research work was met with some resistance. Measurements of energy expenditure were particularly difficult, expecially when I tried to involve the pregnant and lactating women. People often feared the tubes and mouthpieces, and consequently hyperventilated. Women had jewels inserted in their nose which made the use of the noseclip impossible or difficult. The younger ones were quick to sense ridicule and refused to perform outdoor activities with the respirometer. Their reluctance was overcome in the longterm by working with their husbands first, in batches of women friends, or in complete isolation. I also offered a fee to all participants: it was not the benefit to science that would motivate volunteers, but a well bargained remuneration; moreover it compensated for loss of time and for the unpleasantness of the experiment. Many of the difficulties encountered could be foreseen at the start of the project, but as I had hoped, staying in the community one full year gave time to make satisfactory measurements.

## Time Allocation

Direct measurements of energy expenditure need to be coupled with an accurate record of all activities and the amount of time devoted to each daily. Only then can daily energy expenditure be estimated -

multiplying the energy cost of a given task by the time invested in it, summed over all activities. Several methods to determine the allocation of time are at hand: detailed observation budgets, self-annoted diary record, recall questionnaires. The choice of a particular procedure is dependent upon the characteristics of the population (literacy, for example) and conditions in the field, as much as upon the general aims of the research. Indeed there is an inverse relationship between the expediency and acceptability of a study and its degree of precision Ferro-Luzzi, 1982). In the first months of fieldwork, I chose to apply a method of time allocation which was not too intrusive, and which had been applied to other Nepalese communities. Following Acharya and Bennett (1981), the time-use data was generated on the basis of 'spot check observations', visiting sample households at two randomly-chosen one-hour periods during the day to report on the activities undertaken at that time. A statistical compilation of these observations over all the hours of the day for a period of six months or a year gives information on the frequency and distribution of the community's activities. Thus one advantage of the method is that one can obtain time-allocation data on a large sample for relatively little daily work on the part of the observer. It was soon found however that the people of Salme disperse and cover great distances in the course of their work; often they could not all be reached in the chosen hour interval. In such a case, one has to ask those who can be met the whereabouts and doings of their neighbours or kin. This is a serious shortcoming of the method in terms of data reliability; and in many societies, neither the work of men nor of women takes place in the home or in a fixed location. At this point, I turned to establishing a protocole of time budgets; this involves following individuals throughtout their day, recording minute by minute their activities, and results in very accurate and detailed firsthand observations, which can be used in estimating levels of energy expenditure.

To help in continuous time observation, five assistant were chosen, all from Salme village and literate in Nepali. Each was given a digital watch and trained to record the activities of an individual, at a minute interval, in a slim notebook. They were not provided with a pre-existing code of activities, but annoted these in their own words. They worked in two teams, to cover continuously the working hours of the day (from 6 am to 7 pm). If people were to spend the night on the hillside at a fair distance from the village, then they did the same. The assistants were repeatedly instructed not to interfere in the normal pattern of work, as kin or friends might ask them to help with carrying some load or a small child. Diaries were checked and annoted daily, and contained information on time, activity, the geographical area, the presence of children and the social context. Two individuals were followed each day, and received a small fee. Time budgeting, once established as a routine, was found rather successful.

I began with a sample of 32 households who had participated in a food survey the previous year (see the contribution of S. Koppert). These families were not chosen at random, because of general initial animosity towards our work, but were the ones who could be persuaded

to participate by virtue of blood ties or patron-client relationships with our assistants. This does not unduly skew observations as all the villagers are related anyway. I included in the course of the year pregnant women, as soon as their condition could be ascertained; this was a problem indeed since young mothers did not admit they carried child (some believe the foetus 'wanders' in the womb for five months), and clothing (a skirt made from material five meters long, pleated on the stomach, and secured with another long cloth) disguises the state of pregnancy. To record individual variation in working behaviour each adult man and woman was observed on two days, and the total sample (N=78) was covered in three months. In addition, and to disclose seasonal variation, the protocole was repeated on the same sample four times in the course of the year. Thus data was collected on eight days for each individual. Pregnant and lactating mothers, however, constituted a target group (N=10), and were followed two days every month. About 500 time budgets were totalled in the year.

## Evaluation

Although time and manpower consuming when applied to a large sample, and expensive in salaries and remuneration, the continuous observation of individuals offers very detailed information, the wealth of which gives a precise understanding of day to day happenings. Our time budgets reveal in precise hourly terms the diversity of daily activities, and the seasonality of work and leisure. However, since observations were limited to thirteen daylight hours, some working behaviours are not fully represented. Daytime activities, such as agriculture and husbandry, are recorded in their totality, but others, such as rest, lactation and cooking, occur early morning or after dark and are under-estimated; the latter activities are interesting to the extent that they punctuate the working day. Thus the daily budgets measure the total time devoted to the economic tasks, and also reveal the rhyme of activities in terms of productive and non-productive work. They also give precise information on the time necessary to travel on the mountain side and the places covered, on the time investments in childcare, on the importance of social, religious and leisure activities. They document division of labour within a family, the importance of labour exchange between kin or friends ("parma") and of hired labour ("ŋamyak") throughout the agricultural cycle. Finally they witness the distinct lifestyles of the two ethnic groups (Tamang/Ghale and Kami) coexisting in the village, and the degree of their social interaction. The information from time budgets is therefore of interest to scholars of many disciplines. It remains also the only protocole giving data precise enough to be of interest to physiologists.

## Further Aspects of Research

The above plan of research is sufficient for a project which aims to measure the energy expenditure levels in a particular community. However, to answer some important questions in Human Biology, it needs to be complemented with research in related disciplines. The project in Salme village was carried out from 1979 to 1985 by a multidisciplinary team working under the auspices of the C.N.R.S. Estimates of

energy expenditure will be matched with measured energy intakes; this will give a fine appreciation of the energy balance of individuals, and an understanding of the variation existing within a community (Koppert and Panter-Brick, forthcoming). Regular anthropometric measurements complement this information; these were conducted in Salme every three months throughout 2-3 years. Blood, urine and stools samples were also sytematically collected for medical analysis (Meyer, forthcoming). Demographic data was established for the villages on the watershed. A number of geographers and of agronomists described the mountain environment, the pattern of land use, possibilities for the intensification of crop rotation, and also aspects of cattle and forest management. Results will hopefully demonstrate the advantages of moving away from the more limited research any one individual can achieve, to a coordinated multidisciplinary synthesis on man in his ecological circumstances.

A research protocole must be complete enough to answer problems of real importance Castri, 1976; Vayda, 1983); but it must also be kept light to avoid considerable difficulties in implementation. A multidisciplinary project is, first of all, expensive in terms of sending and maintaining in the field the research workers, and in terms of the necessary equipment - with grants less forthcoming in the 1980's. Second, there are problems of organization considering the choice and flexibility of a qualified research team, the time scale and location of the project. Third, longterm presence and interference in the population must be justified to the community and to governments; often this is done by coupling research with aid and development. Some dialogue must take place, and the aims of a project must be made consistent with the policies of local authorities. In Salme, the French Embassy helped towards financing the repair of the school and provided medical supplies. Finally, there are fears for the success of a big project: in having won the participation of the local community in all aspects of research, one must secure it over a number of months until completion. In my experience, people quickly grew tired of endless measurements; conflicts did periodically erupt, especially when work needed to be speeded up or when political factions chose to measure their strenght and debated which benefits should accrue the villagers. My position depended on the voice of my assistants, who were nonetheless caught in a dilemma, having to manipulate their people for my sake and to manipulate me to their own advantage. Over time, the project overcame endless stumbling blocks, and succeeded with patience, tenacity, a blend of humour in dialogue, owing to personal friendships and contracts of renumeration.

# II

# A CRITICAL LOOK AT FIELD RESEARCH

There is today general agreement and awareness that studies of energy expenditure and energy balance do carry important limitations, in terms of the data and theoretical interpretation. Both their reliability and their utility have been questioned.

## Validity of Results

There is first the question of accuracy and reliability of the methodology in the field. The various sources of error attached to energy measurements have been clearly stated by Durnin and Broackway (1959). These are, briefly, inaccurate recording of the duration of activities, failure to define single activities, errors in measuring metabolic cost, untypical behaviour of the subject under observation. To minimize bias, it is crucial to obtain very good time allocation data, as inaccuracies will quickly generate error when multiplying time and energy cost for each activity. Next, sampling activities representatively and measuring the existing range of variation can give better estimates of energy expenditure. The same recomendations apply to the measurement of energy intake (Ferro-Luzzi, 1982). The total margin of error attached to final results may be as much as 10-15% (Durnin, 1978). But this may be acceptable if it represents random "noise" which does not systematically distort results. In any case, published quantitative values of daily energy expenditure and intake can only be accepted as "best" estimates of the "true" level of energy balance.

Some scholars would contend, then, that physiological conclusions based on field research are not validated by such low degree of data accuracy. To be critical of fieldwork data is a virtue but to demean them is a little hasty. Studies in the field are distinct from laboratory experiments (which, of course, are best able to control the sources of measurement error), and their contribution is to take us to local communities and the ecological context; thus objectives may be to measure rates of energy expenditure in everyday working behaviour, rather than to assess work capacity in standardised conditions. For just this reason, and even if they are not perfect, field data have an impact on current knowledge in physiology. This has been felt in the following three aspects. The work of Fox (1953) in Gambia documented that energy balance (shown in fluctuations of weight) need not be achieved over a number of days as frequently considered in the laboratory, but over a matter of months, when a "hungry season" is to be endured each year. In contrast the community in Nepal seems to survive on a tight but stable energy budget throughout the year: there is a regular input of work in tending a number of different crops, which are planted at different altitudes and come to ripen in succession in the course of the year; the monsoon months are nonetheless more demanding in the work effort. The data collected measures the energy balance of individuals over the year's seasonal cycle: such

long period of observation is seldom undertaken in Human Biology, although the problems associated with seasonality are currently gaining much attention (Chambers et al., 1981). Secondly, studies have documented the possibility of population groups living in apparent negative nitrogen balance. In particular, the study of Norgan, Ferro-luzzi & Durnin (1974) in Papua New Guinea gave quantitative indication of the relative risk to pregnant and lactating mothers. These women may neither increase their food intakes, nor afford to reduce their activities but draw upon their body stores of fat when they are bearing or caring for children (Harrison et al., 1975). My project in Nepal grew out of a concern to investigate this problem, and to measure the little-known time and energy stresses associated with motherhood. Thirdly, studies of non-Caucasian populations have led to a revaluation of our standards of health and energy use. The FAO/WHO energy allowances for pregnant women are projeted from the costs of building new tissues and bearing physical movement, and recomend an extra 300 Kcal per day in the diet; but the evidence from free-living populations gives a very different picture with respect to "requirements". Again, many communities are capable of remarkable work effort while rather short in stature, light in weight and poorly nourished according to Western standards. Our Nepalese community is another example of this "paradox": men and women are able to carry loads of forty kilos up steep hills, in spite of low levels of iron in their blood and apparent anaemia.

My conviction, then, is that fieldwork data are both important and relevant. If so, they must be communicated to planners, so that practical implications may follow and be rooted in the analysis of this information. Planners are keen to foster aid and development, but often lack the in-depth integrated data that field research should provide. Once again, dialogue must again take place between research workers, officials in power, and villagers who also perceive their needs.

## Theoretical Interpretation

Field studies have also been criticised on the grounds of the limited nature of data interpretation. In concentrating on the single variable of energy, and the ways in which individuals and populations harness it, several studies have been guilty of partiality (to the extent of "calorific obsession") or reductionism towards other important priorities in the local system. Some have too readily equated energetic efficiency with adaptive success, even where energy was not a limiting factor (Smith, 1979). They also have tended to ignore the factors of change (Vayda and McCay, 1975). As a single-stress approach, models of energy flow have been criticised for not accounting or explaining human societies (Burnham, 1983), since social processes play such an important buffer role with the environment, and have their own priorities in the local system.

However, studies in energy use help in quantifying the relationships and interactions of man with his environment (Brooke Thomas et al., 1983). Hence they enable one to describe levels of energy balance

in a community, to account for health and nutritional status, and to research into the regulation of energy balance. Models of energetics also provide concepts and an organising framework (Haas et al., 1977) which help answering some of the leading questions in Human Biology on human variation and human adaptation to the ecological context. It does seem, here, that field studies can avoid many limitations by inscribing themselves in a multidisciplinary effort; the IBP programme accomplished this in the Andes (Baker and Little, 1976), and the C.N.R.S. in the Himalayas (G.R.E.C.O). My own data must await final analysis, but I may here sketch two examples from the Salme community, to support this general contention: human strategies for coping with particular problems of the environment are intelligible from data on energetics, and best interpreted and extended with findings from other disciplines.

## The Mobility of "goth"

The Tamang/Ghale people of Salme live in the village at an altitude of 1850 meters, but exploit an area which extends from 1200 to 3000 meters; it comprises terraced land, communal grazing grounds and forest. In the course of daily work, they cover great distances on terrain abrupt and often difficult. One finds that travel and portering are very expensive in terms of both time and energy. To answer this problem, they rely on building temporary shelters of wooden posts and bamboo mats ("goth" or "gora"), which they carry to the fields, and where one or several family members may elect to stay. The goths are dismantled, carried, and set up again whenever needed. Since individual holdings are fragmented and also scattered, the goths are moved often, every three or four days, from one small terrace to another. This aspect of their social organization is fundamental in the following aspects.

It follows an agronomic rationale. The goths serve to shelter both those working in the fields and those in charge of cattle. The cattle are parked in the goth at night and serve to fertilise the very fields which will be ploughed and planted; thus people avoid the task of carrying dung. The animals are then kept away from standing crops, but taken to the fields as the harvest proceeds to feed on crop residue. Since the crops are planted in careful rotation at different altitudes, the cattle and the goths move seasonally throughout the mountain slope. Broadly speaking, in the monsoon they move from the higher pasture grounds away from the lower and middle altitude grounds where rice, millet and maize are growing; in the dry season, they are taken down from the higher grounds away from the winter crops of wheat and barley. Indeed, the cycle of agricultural work and the movement of cattle are coordinated very tightly, but it is by no means uniform. The displacement of the goths follows a logic or rule which is necessarily different for all households, according to the land and the cattle resources of each family.

The full use of the goth is a means of considerable economy in the work effort, in spite of having to transport these structures (four to five loads of forty kilos a time): the possibility of overnight shelter in the fields cuts down the time and energy spent in travelling to and fro the village, time which may amount to more than an hour of daily commuting. Indeed some people choose to remain in their goth for weeks on end, and return to the village only for provision of foodstuffs or important social events. The goth makes for an intelligent labour distribution. Family members can separate to meet simultaneous labour requirements in the village and on the hillside; distinct families may choose to pool labour and cattle resources in sharing the same goth, and move it to exploit the terraces of their ownership. The goth and its cattle can be rented out to those who do not have the means of fertilising thus and ploughing their fields.

Living in the goth is also an expression of cultural values. People above all enjoy this life where they feel an affinity with the mountain and the oxen, cows, buffaloes, sheep or goats they posess. They express also a taste for a certain independence and mobility, keeping family groups fluid with changing residence.

In all, the mobility of the goths constitutes an excellent strategy to cope with the constraints of the mountain ecosystem. It is, however, the result of a cultural choice made by the population in exploiting the environment. There are other possible lifestyles: the Tamang of villages at lower altitude (Bumtang) have relinquished this mobility in order to intensify their mode of production, while the distinct ethnic group in Salme, the Kami blacksmiths, do not espouse it. Thus the institution of the goth is best interpreted in the framework of an ecological model, which integrates the concepts of both biological and social adaptation (Dyson-Hudson and Little, 1983). It is a strategy answerable to patterns of energy flow, but dictated by cultural and social history.

## The Strategies of Childcare

Mother-child relationships have been until recently (Nerlove, 1974; Jelliffe, 1979; Popkin, 1980; Lee, 1980) a poorly considered area in Human Biology, although clearly they are an important component of a community's adaptation to its ecosystem. The concept of adaptive strategies of childcare fits here more strictly with those of reproductive success and fitness in evolutionary terms. In Salme, I sought to look at the reproductive performance of women in a holistic and multidisciplinary perspective. Few studies have measured the energy expenditure of mothers in field conditions (Blackburn et al., 1976; Schutz et al., 1980); the description of the work pattern of the women in Salme aims to quantify the extra physiological cost involved in pregnancy, lactation and the carrying of small children. From the Weighed Food Survey are estimated the daily individual food intakes of the women and their children. Regular anthropometric and medical measurements reveal their general health and physique, and portray

infant growth in the first three years of life. The time budgets describe in detail the work investments of women, and establish the ways in which they cope both with tasks in the productive sphere, and with the tending of small children. Certainly, most women continue all activities up to the term of pregnancy, performing even strenuous tasks such as the carrying of wood, but may be working at a slower rate. After the delivery of the baby in the husband's home ("ghar"), and 8 to 12 days seclusion, they resume their usual responsibilities. Since they must always be with the baby to breastfeed, they carry it in a cot ("jholangue" or "goyong"), slung on the back and supported by a head-strap. This leaves them free to perform their ordinary tasks, and even carry loads with the cot secured on top. Most mothers cannot afford to discard their economic duties for long, except in times of seasonal lulls. As the baby grows older (around age two) it is increasingly left behind to play in the village, or under the supervision of another family member.

There are however established differences in childcare strategies between the two ethnic groups living in Salme. The Kami women need not be so mobile, and to always carry their children, since they have very few fields outside the village. They marry and live with their spouse at a younger age and have children on average every two years, whom they feed and look after rather well. In contrast, the Tamang/Ghale retain strong contact with their natal home ("Maithi") away from the husband, and achieve smaller family size, with possibly comparatively less healthy children. The aims of this research are to integrate the various energetic, nutritional, demographic and cultural factors in the analysis of the data, to explain the different practices of child-care, to discuss which are successful, and how these strategies may be seen as components of adaptation to local ecological circumstances.

## Conclusion

Field studies operate within the limits of the possible and the aceptable, working with constraints of time, finance and personel on the part of the anthropologist, and of willingness on the part of the community. In spite of some shortcomings, they contribute importantly in two ways: in giving a quantitative appreciation of the levels of energy balance in an ecological context, and in offering a perspective to answer some theoretical questions on human variation and adaptation to local environments.

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## REFERENCES

Acharya, M., and L. Bennett, 1981. *The rural women of Nepal: An aggregate analysis and summary of 8 village studies.* Centre for Economic Development and Administration, Tribhuvan University, Kathmandu, Nepal.

Baker, P.T., and M.A. Little, (editors), 1976. *Man in the Andes: A multidisciplinary study of high altitude Quechua.* Stroudshburg, Pa.: Dowden, Hutchinson and Ross.

Blackburn, M.W., and D.H. Calloway, 1976. "Energy expenditure and consumption of mature pregnant and lactating women" *J. Am. Diet. Assoc.* 69: 29-37.

Bradfield, R.B., 1971. "A technique for determination of usual daily energy expenditure in the field". *Am. J. Clin. Nutr.* 24: 1148-1154.

Brooke Thomas, R., S.D. McRae, and P.T. Baker, 1983. "The use of models in anticipating effects of change in human populations." In G.A. Harrison (ed.), *Energy and Effort,* pp. 275-281.

Burnham, P., 1983. "Energetics and Ecological Anthropology: Some Issues" In G.A. Harrison, (ed.), *Energy and Effort,* pp. 229-241.

Castri, F. di, 1976. "International, interdisciplinary research in ecology: some problems of organisation and execution. The case of the Man and the Biosphere (MAB) programme". *Human Ecology* 4: 235-246.

Chambers, R., R., Longhurst, and A. Pacey, (editors), 1981. *Seasonal dimensions to rural poverty.* London: Frances Pinter.

Durnin, J.V.G.A., 1978. "Indirect calorimetry in man: a critique of practical problems". *Proc. Nutr. Soc.* 37: 5-12.

Durnin, J.V.G.A., and J.M., Brockway, 1959. "Determination of the total daily energy expenditure in man by indirect calorimetry: assessment of the accuracy of a modern technique". *British J. Nutr.* 13: 41-53.

Durnin, J.V.G.A., and A. Ferro-Luzzi, 1982. "Conducting and reporting studies on human energy intake and output: suggested standards". *Am. J. Clin. Nutr.* 35: 624-626.

Durnin, J.V.G.A., and R. Passmore, 1967. *Energy, work and leisure.* London.

Dyson-Hudson, R., and M.A., Little, (eds.), 1983. *Rethinking Human Adaptation: Biological and Cultural Models.* Westview Press, Boulder.

Edmunson, W., 1979. "Individual Variations in Basal Metabolic Rate and Mechanical Work Efficiency in East Java". *Ecology of Food and Nutrition* 8: 189-196.

WHO, 1973. "Energy and Protein Requirements. Report on a joint FAO/ WHO adhocexpert committee". World Health Organization technical report series no. 522.

Ferro-Luzzi, A., 1983. "Meaning and constraints of energy-intake studies in free-living populations". In G.A. Harrison, (ed.) *Energy and Effort*.

Fox, R.H., 1953. "Energy expenditure of Africans engaged in various activities". Thesis for Ph.D., London University.

G.R.E.C.O., "Himalaya-Karakorum", contributions from C.Panter-Brick, G.Koppert, F.Meyer, I.de Garine, to be published by the C.N.R.S. (Centre National de la Recherche Scientifique), Paris, in 1986.

Haas, J.D., and G.G., Harrison, 1977. "Nutritional Anthropology and Biological Adaptation". *Ann.Rev. Anthropol.* 6: 69-101.

Harrison, G.A., (editor), 1983. *Energy and Effort*. London: Taylor & Francis Ltd.

Harrison, G.A., A.J., Boyce, C.M., Platt, and Serjeantson, 1975. "Body composition changes during lactation in a New Guinea population". *Annals of Human Biology*. vol. 2, no. 4, 395-398.

Jelliffe, D.B., E.F.P., Jelliffe, F.T., Sai, P., Senanayaka, 1979. *Lactation, Fertility and the Working Woman*. International Planned Parenthood, England.

Lee, R.B., 1980. "Lactation, Ovulation, Infanticide, and Women's Work: A Study of Hunter-Gatherer Population Regulation". In M.N. Cohen. et.al. (eds.) *Biosocial mechanisms of population regulation*, (Yale).

Nelms, J.D., 1982. "Measurement of Work and Effort - Physiological Aspects". In G.A. Harrison, (ed.), *Energy and Effort*. p. 1-25.

Nerlove, S.B., 1974. "Women's workload and infant feeding practises: A relationship with demographic implications". *Ethnology*. 13: 13: 207-214.

Norgan, N.G., A., Ferro-Luzzi, and J.V.G.A., Durnin, 1974. "The energy and nutrient intake and the energy expenditure of 204 New Guinea adults". *Phil. Trans. Roy. Soc.* (London) B 268: 309-348.

Passmore, R., and J.V.G.A., Durnin, 1955. "Human energy expenditure". *Physiol. Rev.* 35: 801-840.

Popkin, B.M., 1980. "Time Allocation of the Mother and Child Nutrition". *Ecology of Food and Nutrition.* 9: 1-14.

Schutz, Y., A., Lechtig, and R.B., Bradfield, 1980. "Energy expenditures and food intakes of lactating women in Guatemala". *Am.J. of Clin. Nutr.* 33: 892-902.

Smith, E.A., 1979. "Human adaptation and energetic efficiency". *Human Ecology: An Interdisciplinary Journal.* 7: 53-74.

Vayda, A.P., 1983. "Progressive contextualization: Methods for research in Human Ecology". *Human Ecology.* 2: 265-281.

Vayda, A.P., and B.J., McCay, 1975. "New directions in ecology and ecological anthropology. *Ann. Rev. of Anthropol.* 4: 293-306.

Vayda, A.P., 1983. "Progressive contextualization: Methods for research in Human Ecology". *Human Ecology,* 2: 265-281.

Verma, S.S., M.S., Malhotra, and J., Sen Gupta, 1979. "Indirect assessment of energy expenditure at different work rates". *Ergonomics* 22:1039-1044.

Weir, J.B. de V., 1949. "New methods for calculating metabolic rate with special reference to prptein metabolism". *J. Physiol.* London: 109: 1-9.