CHAPTER 20

ADAPTIVE ASPECTS OF FOOD CONSUMPTION AND ENERGY EXPENDITURE – BACKGROUND

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INTRODUCTION

Like all mammals, humans are subject to constraints related to their nutritional needs, although their dietary behaviour varies widely from the entirely vegetarian diet of Hindus to the Inuit diet composed almost entirely of meat (Newman, 1975; Haas and Harrison, 1977; Froment, 1986). In this section, besides demonstrating this range of human biological variation, we examine how far this variation is explained by adaptive mechanisms which operate at both the biological/physiological and the behavioural/social levels (Waterlow, 1986), and the extent to which social and dietary changes can affect the health of individuals and populations in tropical forest.

CONCEPTUAL FRAMEWORK

Assessing nutritional needs and standards

Simply put, nutritional needs are organic states corresponding to the qualitative and quantitative lack of food. It must be pointed out, however, that their origin is not solely metabolic but also affective and symbolic, aspects which are developed later in this volume (Section 6). In order to define and quantify nutritional needs, a better knowledge of the magnitude of human adaptive capacities is necessary, especially in the populations of developing countries. Indeed, the current energy and protein intake recommendations formulated by successive expert committees (FAO/WHO, 1973; FAO/

WHO/UNU, 1985) are still the subject of debate and difficult to apply to real life situations. In particular, they do not take into account phenotypic plasticity: individuals and populations have capacities which enable them to adapt to particular stresses so that the theoretical and actual needs of a population may not be the same. Energy requirements in the tropical forest are assessed according to different empirical and experimental methods, for example by Pasquet *et al.* (1993, this volume). A critical view of the methods used for assessing nutritional needs is offered, for example, by Holmes (1993, this volume) who raises the question of the appropriateness of the standards defining "desiderable" growth in children in environments where food is scarce. Experimental (controlled) and free living models have been used for the study of adaptation. Among these, seasonal fluctuations in food availability and work load, like those observed by Pagezy (1990), are a convenient tool for studying the responses and coping strategies of individuals and communities undergoing energy stress under real-life circumstances (Ferro-Luzzi, 1990). For example, Bailey *et al.*, (1993, this volume) have clearly demonstrated that in the Ituri the seasonal variations in food availability have tangible effects on ovarian functioning and thus on the distribution of births throughout the year.

Biological and behavioural adaptations

Short stature with corresponding low body weight in children and adults is considered by some authors (Frisancho *et al.*, 1973; Stini, 1975) to be a primary adaptation to energy shortage: a finite quantity of food can maintain a larger number of small individuals since less energy is needed to maintain health, activity and growth.

Another well recognized energy-saving strategy is adaptation by altering metabolic rate. In chronically undernourished Indian labourers, for example, basal metabolic rates (BMR, the minimum energy expenditure for maintenance of basic body functions and growth) were reduced by 13.7% kg^{-1} lean body mass compared with well nourished control subjects (Shetty, 1984). Kurpad *et al.* (1989) also reported reduced diet-induced thermogenesis (DIT). Possible long-term adaptations explaining inter-populational differences have been reported from well controlled experiments by Minghielli *et al.* (1990), who found significant reduction in BMR and blunted DIT in Gambian men compared with European men of the same body composition.

By contrast, there is no rigorous evidence of increased efficiency of muscular work (Waterlow, 1986) although Minghielli *et al.* (1990) showed that net efficiency of walking was greater in Gambian than in European men. However, unconscious postural adjustments have been postulated

which would increase the economy with which work can be performed, so that Kenyan women can carry loads up to 20% of their body weight while walking at an optimal pace without incurring extra energy costs (Maloiy *et al.*, 1986). Another behavioural mechanism has been observed through a reduction in voluntary or conscious activity, whether occupational or discretionary (Viteri and Torun, 1981; Gorsky and Calloway, 1983), although the desirability of such accommodations is questionable.

Sociocultural responses and biocultural evolution

Humans respond to their food requirements through cultural regulations and social relations, which may be maladaptive or adaptive.

In the material and non-material culture of traditional populations, the existence of traits beneficial or necessary to ecological success is not a matter of debate: an example is given in this volume by Ulijaszek and Poraituk (1993) with sago-making in Papua New Guinea, an efficient technique in terms of input/output energy ratio.

It should be emphasized that the adaptiveness of culturally determined traits can move from being beneficial or necessary, so that they turn out to be less adaptive "strategies" after recent, rapid shifts to new demographic, ecological or social conditions that modify dietary contexts: examples are provided in this volume by Ohtsuka (1993), Jenkins and Milton (1993), and Prinz (1993).

Furthermore, one finds numerous examples of dietary practices and habits which are apparently neutral or disavantageous to nutritional status, or even risky for health (Messer, 1984), examples which might support the notion of "the cultural freedom of Man" (Mead and Guthe, 1945; Garine, 1978, 1991). Yet, biosocial studies have emphasized that some sociocultural traits and responses may be strictly determined by nutritional factors which may testify to some biological "wisdom of culture" (Pagezy, 1983, 1993, this volume; Speth, 1987; Greene, 1977).

Katz *et al.* (1974) and Katz (1982) go one step further: on the basis of biochemical and pharmacological data, they argue that nutritionally adaptive consumption practices – such as the alkali processing of maize in the New World, the consumption of fava beans (*Vicia faba)* or bitter manioc where malaria is endemic – would, in the past, have been "selected for" in the cultural pattern of human groups that in turn would have influenced, directly or indirectly, the genetic structure of the populations. This process, in which biological evolution and adaptation is supplemented by cultural factors, was termed "biocultural evolution" by these authors. However, such biocultural evolutionary processes need more explanation if they are to be completely understood. In particular, the feedback

mechanisms by which nutritional advantage is translated into cultural food preferences and practices have yet to be demonstrated. A detailed contribution to the study of a relationship between a specific cultural behaviour (manioc consumption in Africa) and human fitness and evolution is presented by Jackson (1993, this volume).

FOCUS ON TROPICAL FOREST

Staple foods

Whereas the savanna areas are often favourable for cereal production, forest diets are generally based on *Musa* spp. (plantains and bananas), sago palms, and various tuber crops (manioc, yams, taro), although there are some groups in the forests whose diets are based on rice or maize. The staple food tends to be emblematic for each ethnic group, even if it has only been adopted recently in evolutionary terms, for example like manioc or maize in Africa (400 years) which have displaced yams, once the principal source of energy (Coursey and Alexander, 1968).

Manioc is the staple food for least 300 million people worldwide (FAO, 1989). It is perhaps the most important forest staple crop and provokes interesting questions about nutritional adaptation in humans as it has both adaptive and maladaptive features. It has many advantages, being rich in carbohydrate (and thus in energy), simple to cultivate and requiring less work on soils which need little preparation (therefore lower energy expenditure). It is highly resistant (particularly to parasites) and is relatively non-degrading for soils (see, in this volume, Dufour, 1993; McKey and Beckerman, 1993; F. Grenand, 1993). Its disadvantages are its low protein content and the presence of a toxic product – cyanide – with a wide range of damaging effects on human metabolic systems (Jackson, 1993, this volume). The populations who rely on toxic manioc have developed cultural responses for detoxifying it, although ingesting small quantities of the toxin is unavoidable. Furthermore, while unprocessed manioc is rich in calcium, ascorbic acid, thiamine, riboflavin and niacin, work remains to be done on the effect of detoxification on the availability of these important nutrients.

Food and nutrition in the tropical forest of the islands of Southeast Asia and Oceania also differ from those in Africa. This region as a whole was once characterized by a yam-taro-sago cropping complex (Spencer, 1963). Rice was subsequently introduced to most Asian regions as a staple crop, but sweet potatoes of South American origin have become the predominant food in densely-populated highland New Guinea and some other islands in Oceania. *Metroxylon sagu*, grown only in this region, has several attractive features. Like manioc, sago palms, which grow naturally or with minimum manipula-

tion in freshwater swamps, are characterized by low labour input requirements, stable food supply, and contain a large amount of carbohydrate but negligible amounts of other nutrients (Townsend, 1971; Ohtsuka, 1983). However, unlike manioc, detoxification is not required. In Melanesia alone, at least 300 000 people rely on the sago palm as their main energy source (Brookfield and Hart, 1971).

Seasonal variation and energy balance

The weight variations among adults in the forest, even if they are smaller than those observed in the savanna, are witness to the existence of a lean period, or a periodical excess of energy expenditure (Pasquet *et al.*, 1993, this volume). Seasonal scarcity of highly valued foods (such as meat in interior forest communities, or fish in coastal forest communities of Cameroon, Koppert *et al.*, 1993, this volume) can induce the sensation of hunger in a population, hunger which has no real existence on the caloric level (Miracle, 1961; Pagezy, 1982) but is experienced as if it did. These are examples of needs which are not strictly of metabolic but rather of affective origin. Pagezy (1986) showed that in a forest environment seasonal variations in nutritional status went hand in hand with epidemics of serious infectious diseases of childhood (measles, whooping cough, diarrhoeas). Bailey *et al.* (1993, this volume) have clearly demonstrated in the Ituri that these seasonal patterns of food availability have tangible effects on ovarian function and thus on the distribution of births over the year.

Biological consequences

Weisenfeld (1967) showed the relationships between agricultural systems, malaria and sickle cell anaemia. The fact that the Pygmies present sickle-cell anaemia frequencies two or three times lower than among their agricultural neighbours may mean that they are less exposed to malaria, as it was deforestation during the Neolithic which created the *Anopheles* habitats in agricultural areas. Epidemiological studies, like those in Cameroon (Froment *et al.*, 1993, this volume), show that the forest diet is rich and varied as long as population pressure is not excessive. Thus the Pygmies have the highest protein intakes in the world, but this does not prevent them from having a lower life expectancy. This hot and humid environment is in effect propitious to the transmission of numerous pathogens, notably infectious diarrhoeas and intestinal parasites, so that malnutrition is no less frequent here than in the savanna where food availability is more precarious but the environment healthier.

Similar disadvantageous effects of hot and humid forest environments on human health and survival were observed in New Guinea. An attractive hypothetical model was proposed by Stanhope (1970): "There may be a process of slow population expansion in Highland areas with spill-over towards the lowlands.... It is possible that a Highland model before contact would have consisted of an ever-expanding centre spilling over into an ever-dying periphery". The different mortality rates in the two regions largely depend on the different disease patterns, particularly on high incidence rates of malaria and some other infectious diseases in the lowlands. However, this model is also related to people's food consumption patterns. The Highlanders depend largely on sweet potatoes, whereas the lowlanders are much more dependent on less-productive garden crops such as taro, yams and bananas, and sago starch.

A more systematic investigation of the roles of both diseases and nutrition on long-term human survival is needed (Ohtsuka and Suzuki, 1990), particularly when designing nutrition programmes.

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