"Nutritional status of Sub-Saharan African pastoralists: A review of the literature"

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Introduction

It is well-known that the 45 countries of sub-Saharan Africa together exhibit the highest population growth rates, the highest levels of infant and child mortality, and the poorest economy of any major region of the world (ACC-SCN 1987, ACC-SCN 1989). Caloric intakes estimated from national food consumption data are the lowest for any region. Widespread shifts from subsistence to cash cropping and increased access to purchased foods have not always been shown to result in improved household food supply (ACC-SCN 1989, Dewey 1990, ACC-SCN 1992, Kennedy *et al* 1992). Generally adverse socioeconomic and health environments interact to limit the genetic potential for growth in most populations. There are high percentages of low birth weight, of growth faltering in height, weight, head circumference and fatness among children (Cameron 1991), and of chronic energy deficiency syndrome among adults (Ferro-Luzzi 1990b, Ferro-Luzzi *et al* 1992). In contrast to other major regions, however, there is little evidence for higher prevalences of undernutrition among girls than boys (Svedberg 1990), and indeed there is evidence from some communities that, relative to men, women are buffered from environmental stresses (Rosetta 1986, Ferro-Luzzi 1990a, Dettwyler 1992).

The relative situation of sub-Saharan African pastoral populations within this milieu is not well understood. There is continuing debate over whether members of pastoral populations in general are at higher nutritional risk than their more settled neighbours (Hill and Randall 1985, Brainard 1991), about the relative importance of seasonality, disease and sex differences in labor activities as influences on nutritional status (Hilderbrand 1985, Shell-Duncan 1995), and about how best to identify precisely which members of pastoral populations are at highest nutritional risk (Nestel 1985). Here I review published data on nutritional status of African pastoralists located in a retrospective snow-ball search of the peer-reviewed literature, beginning with recent sources listed in the Medline and Melvyl bibliographic databases. Although much additional data can undoubtedly be found in technical reports published by governments and NGO's, this "grey" literature is not reviewed because there is no systematic way to obtain it. The reader is referred to Dowler *et al.* (1986) and Swift *et al.* (1990) for summaries of some of that literature.

Current size of the pastoral population in Africa

There appears to be no simple estimate of the actual number of people directly dependent on pastoralism in Africa. A tremendous diversity of cultures and herding systems are subsumed under the rubric of African pastoralism (Dyson-Hudson and Dyson-Hudson 1981, Little 1989, Bernus 1990, Sperling and Galaty 1990). Lack of a conventional definition of "pastoralism" renders the construction and interpretation of estimates of the numbers of "pastoralists" highly problematic. Over a decade ago, it was estimated that at least 30-40 million people "depended" on some form of livestock as the "principal means of production" worldwide, of whom between 50% and 60% (up to 24 million) lived in Africa (Sandford 1983, p.2; see also Jahnke 1982, who estimated that Africa contained half of the world's pastoral population of 22 million, 9 million of which were "agro-pastoralsists"). Recent national-level census figures reveal a generally high ratio of livestock to people (Galaty and Johnson 1990, p. 9). In 1988-90, the annual average number of cattle living on the continent exceeded 183.7 million, almost 14.5 % of the world total (FAO 1994). Given that the total human population in Africa is only 530 million, or 10% of the world total, we can estimate that there is presently at least one cow per 2 persons overall. This rises to one cow per person if we consider only the agricultural (rural) sector of the population. There were also estimated to be 372 million sheep and goats (21.7% of the world total) and 16.9 million buffaloes and camels (10.7% of world total). The potential economic, ecological and ideological importance of livestock as assessed by livestock/person ratios varies between regions, with the highest livestock:human ratios in east Africa and the Sahelian countries (Sellen 1995).

Nutritional assessment of sub-Saharan African pastoralists.

The nutritional status of individuals and families provides a useful outcome measure by which to assess the effects of socioeconomic and other differences within a population. The nutritional status of a population serves as a valid index of a variety of other health and socioeconomic indicators. Standard methods for the assessment of nutritional status of individuals and populations include: dietary assessment, in which nutrient intakes are estimated for individuals, or population sub-groups, using some combination of survey and observational techniques; anthropometric assessment, in which physical measurements on cross-sectional samples of the population, stratified by age and gender, are compared to reference data from well-nourished populations; biochemical assessment, in which tissue concentrations of various nutrients are assayed using a variety of laboratory-based techniques; and clinical assessment, in which individual subjects are screened for symptoms of nutrient deficiency.

Variation in diet composition

A number of studies have assessed the relative importance of various dietary components at the individual or household level using informant either reports (Loutan 1985, White 1986, Galvin *et al* 1994, Gray 1994), or quantification of production and/or consumption of foods by volume (Selinus *et al* 1971, Benefice *et al* 1984, Loutan and Lamotte 1984, Loutan 1985, Nestel 1986, Ellis *et al* 1987, Homewood 1992, cited Galvin 1992). All pastoralists studied utilize a

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simple diet which consist of three principal groups of foods: milk and milk products; meat, blood, fat and bone; and cereals (Galvin 1992). These groupings are associated with a continuum of procurement strategies, in which milk products and, to a lesser extent, meat products, are most often produced in the household, whereas cereals are most often obtained through trade. A recent review of dietary composition for eight pastoral populations clearly showed that dietary differences among them were quantitative rather than qualitative (Galvin 1992, Figure 3). Milk products and cereals are always the major components of the diet, the former to a more variable extent. The relative annual contributions of different foods to total diets vary substantially among populations (Galvin 1992; Galvin, Coppock, and Leslie 1994). Some populations also utilize wild foods (Becker 1983), and others purchase goods such as tea, sugar and oils (Galvin 1992, p. 213).

Milk and milk products account for more than 60% of the dietary energy of some east African pastoralists (62% Turkana; 64% group ranch Masaai; 66% Ariaal) and around 30% of the dietary energy of most other pastoral groups for which data exist (Borana, Tuareg, Fulani, Tamasheq: Galvin 1992; Galvin, Coppock, and Leslie 1994; but see Lindtjorn 1987, who cites figures of 50% from milk and 16% from meat for Ethiopian Borana). Caloric contributions of milk of less than 20% are reported only for the Arsi Galla (Selinus, Gobezie, Knutsson and Vahlquist 1971) and poorer sections of the Barabaig (Kjaerby and Baynit 1979). Indeed, most pastoral diets reflect traditional preferences for milk, regardless of degree of acculturation and despite wide differences in the degree of involvement in the market economy among pastoral groups (Homewood 1992, Galvin *et al.* 1994, p. 215, Gray

1994). The high protein intakes recorded for some groups (e.g. Benefice, Chevassus-Agnes and Barral 1984) are achieved through high consumption of milk and milk products. Meat consumption is negligible in some groups (Tuareg, Fulani, group ranch Masaai), and is never as important as early reports suggested (Orr and Gilks 1931), accounting for less than 10% of total calories in more than half the populations studied. The importance of cereals is therefore inversely related to that of milk and cultivating pastoralists tend to consume less milk and more cereal (Swift *et al* 1990).

Unsurprisingly, virtually all African pastoralists studied suffer reduced dietary intakes during dry seasons. On the face of it this might be attributed to lowered milk yields when animals are out of condition and indeed all groups studied have significantly lower dietary contributions from milk in the dry seasons versus the wet seasons. However, given the involvement of all pastoral populations in cultivating or trading cereals, it is really due to a failure to substitute purchased cereals sufficient to replace lost household milk production during dry periods and droughts. The underlying reasons for this have not been properly examined. They almost certainly involve unfavorable terms of trade during dry season conditions (higher grain prices, lower market demand for livestock, and poorer condition of sale animals) as well as logistic difficulties in transporting livestock and grain between remote dry season camps and market centers.

Variation in economic activity within populations is associated with differences in dietary composition at least as large as those between populations following different blends of pastoral and non-pastoral subsistence strategies. Recent studies suggest that while material conditions may be very similar for all

members of a given pastoral population, the livestock holdings and farming activities of families may vary substantially (Dahl 1979, Little 1985, Grandin 1988, Borgerhoff Mulder 1991). Whether such wealth differences result in differential food intakes, energy expenditures or disease risk among individuals has hardly been examined (Borgerhoff Mulder and Sellen 1994). Some data indicate that in poorer sections of pastoral populations, and in poorer ecological zones, low milk yields and high livestock mortality result in relatively decreased milk consumption and increased meat consumption (Swift et al 1990). Potential wealth-related differentials are probably modified by social mechanisms such as resource sharing and loaning among family members and between kin or affines. Among lactating Turkana women, all of whom show seasonal increases in consumption of both milk and maize-meal porridge during wetter periods, intakes are higher across all seasons for women who report having larger social networks, for younger women, and for women from households estimated to be of higher socioeconomic status by several qualitative measures (Gray 1994). In general, however, the degree to which members of pastoral populations exhibit socio-economic heterogeneity, and the likely nutritional effects of wealth and social differences, are not well understood. Moreover, although studies of the economic behavior and herd management strategies of African pastoralists are numerous because of programmatic concerns with increased productivity and range land conservation, only a small number have also examined the allocation of the proceeds of livestock production below the level of the household or how these strategies translate into increased food quality or quantity for vulnerable members of the population.

Energy and protein intakes

Table 1 summarizes published estimates of average annual and seasonal energy caloric intakes, protein intakes and estimated energy requirements, among Kenyan Turkana, Kenyan Maasai and Senegalese Fulani pastoralists. Several other studies present assessments of energy intakes relative to contemporary recommendations without presenting the underlying caloric intakes. For example, Selinus, Gobezie, Knutsson and Vahlquist (1971) used 1957 FAO tabulations to estimate that agro-pastoralist Arsi groups had diets generally deficient in energy. Estimates of this type are not considered here because recommendations concerning adequate caloric intakes have changed greatly in the last 40 years.

In the absence of any data on functional outcomes it is difficult to properly assess the adequacy of the macronutrient intakes reported in Table 1. The problem is complicated by broad lumping of data across age and sex groupings and ignorance about effects of work activities and metabolic adaptations on actual energy requirements. The caloric intake figures are clearly as low as those in other rural populations where chronic energy deficiency has been recorded among adults (James et al 1988, Ferro-Luzzi et al 1992, Immink et al 1992) and are best interpreted as inadequate (Nestel 1989). Nevertheless, it is possible that the actual caloric needs of pastoral peoples may be lower than those of other populations. The role of body composition, activity patterns, physiological buffering mechanisms and ontogenetic adaptations of reproductive physiology in modifying macronutrient requirements is poorly understood (Leslie et al 1984, Little et al 1988, Ferro-Luzzi 1990b, James et al 1990). To the extent that functional outcomes are not impaired, energy intakes could be "adequate" in the

Table 1. Estimated food intakes and requirements for African pastoralists

Population	Annual energy intakes (kcals/person /day)	Wet season intakes (kcals/person /day)	Dry season intakes (kcals/person /day)	Protein intakes (g/person /day)	Sources
Fulani (Senegal) All individuals	2,231 [a]	2,005 [a]	2,619 [a]	52.3 [a]	Benefice *et al* 1984
Maasai (Kenya) Women and children > 2 years old	1,080	832	1,248		Nestel 1985, Nestel 1986
Women	1,222 ±506	-	-	44.9 ±21.6	Nestel 1989
Turkana (Kenya) All individuals > 2 yrs old	1,340	1,434	1,308		Galvin 1985
Women and children	1,009	1,103	979		Galvin 1992
Estimated adult requirements: All individuals >2 yrs	1,655 [b]	1,710 [b]	1,599 [b]		
Women and children	1,255	1,269 [b]	1,241 [b]		Little *et al* 1988
Fulani (Niger) All individuals	2,344	-	-	-	
Tuareg (Niger)					Bernus 1988
All individuals	1,855	-	-	-	Bernus 1988

Notes: S.D.'s are shown when reported; a. averages taken across sub-groupings of original data; b. reflects averaging across all relevant age and sex groups of original estimates (in Little, Galvin, and Leslie 1988, Table 12.2) across several months of "dry" season.

particular ecological contexts in which the populations subsist. Even where slow child growth, delayed adolescence and small acheived adult body weights are concomitantly observed (Nestel, 1989, Galvin, Coppock, and Leslie 1994), low caloric intakes must be considered but one of several possible causes. Adult protein intakes have been found to exceed recommendations based on Western reference populations for at least some of the year (Selinus, Gobezie, Knutsson and Vahlquist 1971; observations during the harvest season). There are no studies of young child diets which examine whether protein intakes are growth-limiting.

Micronutrient intakes

Studies of micronutrient consumption are extremely rare, despite the knowledge that staple foods such as milk and maize are low in certain nutrients (particularly iron and vitamins A and C). Selinus, Gobezie, Knutsson and Vahlquist (1971) estimated that Ethiopian Arsi groups ate diets seasonally deficient in iron and generally deficient in calcium, vitamin A and ascorbic acid. This was true even for individuals estimated to be consuming sufficient calories. Weaning diets were estimated to be particularly deficient in these micronutrients, and also thiamin, niacin and riboflavin. Nestel and Geissler (1986) also estimated that iron and ascorbic acid intakes were low among Kenyan

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Maasai women and children, and suggested the cause to be low dietary intakes rather than poor dietary quality. In contrast, Benefice, Chevassus-Agnes and Barral (1984) estimated that intakes of iron, calcium, copper, magnesium, niacin and vitamin B12 were adequate at all times of the year among a population of Senegalese herders (predominantly Fulani). Seasonal deficiencies in intakes of vitamin A, vitamin C, thiamin and zinc were estimated to occur, but deficiencies in some seasons were compensated by intakes in excess of estimated requirements during the rest of the year. Only folate and riboflavin seemed to be perennially deficient.

These studies suggest the major sources of micronutrients vary somewhat among populations with composition of the diet. Among the Arsi, cow's milk was the main source of calcium, cereals were the main sources of iron, and onions the main sources of vitamin C (Selinus, Gobezie, Knutsson and Vahlquist 1971). Cow's milk or camel's milk was also the major source of vitamin C among, respectively, Masaai (Nestel, 1986) and non-refugee Somali (Magan et al 1983). Cow's milk was found to be the main source of vitamin A and riboflavin among the Senegalese . Although cow's milk was also a major source of vitamin C among the Senegalese a substantial amount was derived from purchased vegetables and wild plant foods (Benefice, Chevassus-Agnes and Barral 1984), which were also a rich source of vitamins A, B2 and C (Becker 1983). The main sources of iron were drinking water and commercial (rather than locally grown) maizemeal for the Masaai.

A handful of studies have examined the retention of micronutrients in milk and meat products prepared and stored in rural settings, but few pertain to sub-Saharan Africa (see Amr 1990, Al-Zawawi and Caldwell 1993 for discussions of Middle Eastern practices). It has been suggested that fermentation of milk can reduce its vitamin C content (Gatenby-Davies and Newson 1974, Gomez 1982), while fermentation of sorghum and millet decreases tannin content and possibly other dietary inhibitors (Holter 1988, Mbugua et al 1992). Taken together these studies provide conflicting evidence as to the the appropriateness of traditional methods of food storage and preparation. More work is needed in this area, especially to show how specific practices may translate into improved nutritional status.

Anthropometric status of children

Nutritional classification of pastoral children presents a special problem in that birth records do not usually exist for these populations (Borgerhoff Mulder 1992, Shell-Duncan 1995). Age determination then depends on reproductive interviews with parents and subsequent estimation of the timing of births by means of a calendar of local events. Ideally, age rankings of children from multiple informants should correspond to each other and to the ages determined by the event calendar. Such detailed ethnographic data are difficult to collect and verify in short-term studies. Uncertainty in the age classification of children surveyed may necessitate the use of unconventional age breakdowns in the presentation of findings, often having limited biological meaning, and it appears that this may have occurred in at least some studies published. It can also lead to a strong reliance on weight-for-height standards for nutritional assessment, which do not depend on accurate age estimation, rather than on the more informative age-specific standards. For children, weight for height (W/H) is the most easily applied and, until recently, the most commonly used anthropomet-

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ric measure of nutritional status in community surveys.

Published studies which have estimated the extent of undernutrition in sub-Saharan African pastoral populations using child anthropometry are few and their results vary greatly (Table 2, following pages). Unfortunately, much of the variance in estimates among studies may be attributable to differences in the reference data chosen for comparison, in the choice of age-groups measured, and to the presence or absence of famine conditions at measurement, so that only very tentative comparative conclusions can be drawn. To render different studies somewhat comparable, broadly equivalent cut-off values were used to estimate the prevalence of wasting (chronic undernutrition) from the reported data. Alternative cutoffs of either -2 standard deviations of the corresponding W/H age/sex mean in the NCHS reference data, or of 80% of the corresponding W/H median in the Boston reference data yield estimates of undernutrition which range between 0% to over 50% of pastoral children. For children under 5 years, and excluding the studies carried out after the Sahelian drought of 1973-4 and the Ethiopian drought of 1983-5, estimates of the prevalence of nutritional wasting (acute malnutrition) range between 0 and 24%. Where other indicators such as height for age or (H/A) or weight for age (W/A) are used the variance among studies also increases, probably due in part to inaccuracy of age estimates for the subjects.

In all but one study where age effects were noted, the prevalence of undernutrition by W/H or other measures increased with age, being higher among older children than infants, and highest among teenagers. Sex differences were reported in two studies (both reported in Wagenaar-Brouwer, 1985), but these were inconsistent in direction and across age groupings. Thus, the effects of poor growth accumulate across the lifespan, and no population-wide catch-up growth is observed. No studies examine the possible influence of increasing work activities on energy balance as growing children take on new productive roles.

Seasonal effects on child growth have rarely been investigated. On one hand these cannot be assessed from body weight changes alone in growing children, and on the other, small samples result in low statistical power to detect changes in skinfold thickness' of very lean subjects. In several studies, skinfolds and arm circumferences were found to be more likely to fluctuate with season than indices of body weight. In all but one study where the effects of season were noted or quantified, there was a seasonal effect on prevalence or mean values of W/H among children, and in that study other indicators were found to differ by season. Nevertheless the direction of seasonal effects on child anthropometry apparently differs among the samples. For the 13 studies reviewed, the seasons of lowest nutritional status were the late dry (Fulani: Loutan and Lamotte 1984; Rendille: Nathan *et al* 1996), the late wet (Fulani: Wagenaar-Brouwer 1985), the early wet (Fulani: Hilderbrand 1985), the dry (Kel-Tamasheq: Wagenaar-Brouwer 1985; Arsi, Borana: Lindtjorn *et al* 1992), both the late dry and early wet (Shell-Duncan 1995) and unreported (Fulani: Benefice, Chevassus-Agnes, and Barral 1984).

These discrepancies may derive from problems with the definition of seasons, the effects of inconsistent rainfall patterns in different years, or differences between regions exhibiting bi-modal and uni-modal rainy seasons. Whenever children are reported to suffer no seasonal effects, it is not always clear whether seasonal changes havebeen obscured by

Table 2. Comparison of children's nutritional status among African pastoralists: estimates of prevalence of low weight-for-height (W/H)

POPULATION	n	% <80% median (or Z<-2SD)	% <90% median (or Z<-1SD)	Seasonal effects observed	Sex / age/ settlement differences observed	Survey methods, timing & other notes
Burkina Faso "migratory populations" a	166	37.2	-		Higher prevalence among children over 10. All estimates of malnutrition higher for migratory than sedentary groups, where prevalence was lower among teenagers than among children under 10 years.	Single survey, July 1973. Clinical assessments of malnutrition also presented.
0-9 yrs	132	36.0	-	Not discussed		
10-14 yrs	34	43.0	-			
Mauritanian "Nomads" b						
0-14 yrs	781	16.6	-	Not discussed	Prevalence of low W/H twice that among 'sedentary' communities.	10-week survey of several ethnic groups in several regions, July-Sept 1973.
Senegalese Fulani (Ferlo) c	233	11.1	-	No; but MUAC & skinfolds differed significantly by season (direction not reported)..	No differences in 5-9 yr-olds; higher prevalence among boys 0-4 and girls 10-14. Mean H/A and W/A as % of standard increased with age.	Longitudinal repeated measures, 5-monthly, March 1980-June 1981. Data retabulated here. Clinical estimates also presented. Sample biased towards girls (104 boys, 129 girls).
0-4 yrs	114	3.5	26.3			
5-9 yrs	58	15.5	59.9			
10-14 yrs	61	21.3	75.4			
Nigerien Fulani d	?			Yes; weight gain of 0-5 year-olds stopped at end of dry season; skinfolds, but not MUAC, dropped relative to standards.	Not discussed	Longitudinal repeated measures, 3 -monthly, August 1980-September1981
0-5 yrs	29	7-17	-			
Unspecified	62	5-15	-			
Malian Fulani (Niger Delta) e	150	-		Yes; prevalence of low indicator values increased in late wet season for all age groups.	Sex differences in 6-15 yr olds only: maxima and minima of prevalence lower for boys than girls.	Longitudinal repeated measures, monthly, June 1981-May 1983. Upper caste (Fulbe) scored lower than subordinate caste (Rimaibe).
0-5 yrs	50	0-16	15-48			
6-15 yrs	100	0-22	-			

Population / age group	n			Seasonal change	Sex differences	Study design
0-5 yrs	50	0-16	15-48	indicator values increased in late wet season for all age groups.	…differences in 0-13 yr olds only: maxima and minima of prevalence lower for boys than girls.	*Longitudinal repeated measures, monthly, June 1981-May 1983. Upper caste (Fulbe) scored lower than subordinate caste (Rimaibe).*
6-15 yrs	100	0-22	–			
Malian Kel-Tamasheq (Tuareg)[e]				Yes: depending on age, estimates of prevalence changed with time; no under-5's found below 80% at any time; older children & adults show seasonal changes.	Slightly higher prevalence among children over 5 years. Among 5-17 year-olds, boys at slightly higher risk.	Longitudinal repeated measures, monthly, June 1981-July 1982; present data from July & March of 1983. Adult weights varied by season, but in opposite directions in two separate samples from separate camps.
0-5 yrs	?	0	11-16			
5-17 yrs	?	3-7	24			
Malian Fulani (Seno-Mango area)[f]	?	?		Yes: higher prevalence of low W/A at start of rains (end of long dry season).	Not discussed. *calculated here as proportion of 93 child-measures pooled from all surveys falling below 80% of standard W/A on published graphs.	Longitudinal repeated measures, monthly, 1982-1983; quarterly results presented.
(i) 6 mo - 5 yrs	62	18.9-24	–			
(ii) 0-36 mo	45?	50.5*	–			
Kenyan Turkana[g]				Yes; a period of minimal growth in height and MUAC coincided with the dry season; effect was small and, author argues, unlikely to be related to food availability	Slightly lower nutritional status among girls than boys, but little difference in seasonal changes.	Longitudinal repeated measures, monthly, on nomadic children, Feb-Nov 1990
0.5-2.9 yrs	27	29.6				
3-10 yrs	27	33.3				
Kenyan Maasai[h]	411*	28.7		Not discussed	Prevalence of low W/H increased with age; prevalence of stunting peaked in 2-5 and 9-14 year-olds. Sex differences not discussed.	Longitudinal repeated measures survey, bi-monthly, Jul 1982-Jun 1983. *Prevalences derived from 1421 child-measurements made over a year
0-1.9 yrs	237	15	38			
2-4.9 yrs	271	23	67			
5-8.9 yrs	451	21	69			
9-13.9 yrs	360	41	82			
14-17.9 yrs	102	66	88			
	1421					
Tanzanian Maasai[i]				Authors suggest that their results represent a seasonal minimum.	Poor representation of 5-17 age group confined report to data on young children and adults.	Single cross-sectional nutritional survey, June-July 1989. Opportunistic sample of 66 bomas, stratified by location and size.
0-5 yrs	188	19	57			

Population / age	Sample size				Findings	Survey description
Kenyan Turkana [j] (settled)	236			Not discussed	Children under 4 years were smaller in most dimensions than nomadic Turkana children; older children were larger than nomadic children. No obvious sex differences.	Cross-sectional survey of a stratified age/sex sample, "post-harvest", 1979. W/A, H/A and body composition measures also reported.
1-4 yrs	70	9	36			
5-10 yrs	166	5	57			
All ages	236	7	51			
Kenyan Rendille [k]					Prevalence of low W/H lower among nomads in both wet and dry years; prevalence of low W/H higher in the "dry" year for both settled and nomadic groups	Initial dry season cross-sectional survey, July 1990 (a wet year) with follow-up in June 1992 (a dry year). Dietary intake and morbidity assessed in both rounds.
0-6 yrs	174	6-23	78-98	–		
Botswanan Herero/ Tswana/!Kung [l]				Not discussed	No differences in prevalence of low W/H by school attendance or by ethnic group; prevalence of low W/H decreased among !Kung over 20 year period of sedentarization and switch to pastoralism.	Cross-sectional surveys, July 1987.
0-19	97, 91	2-6	–			
Ethiopian Borana [m]				Not discussed	Prevalences of low (<80%) and extremely low (<70%) W/H and kwashiorkor lower than among non-pastoralists in lowland, semi-arid areas	61 community surveys by relief, church and mission organizations during the Ethiopian drought and famine, 1983-1985.
1-5 yrs	81-319 per survey	0-60.7 (means varied 16.8-19.2 by year and area)	–			
Ethiopian Arsi [m]				Not discussed	Prevalences of low (<80%) and extremely low (<70%) W/H and kwashiorkor lower than among non-agro-pastoralists in lowland, semi-arid areas	38 community surveys by relief, church and mission organizations during the Ethiopian drought and famine, 1983-1985.
1-5 yrs	89-174 per survey	0-57.2 (means varied 11.2-34.5 by year and area)	–			

Kenyan Turkana [n] 0-18 yrs	325	No nutritional classification	-	Authors suspect	Mean heights and weights of teenagers of both sexes further below standards than those of under-10s.	2 cross-sectional surveys, Mar-Apr 1982 (late wet), Dec-Mar 1982 (late dry). Provide means & SD's of wt & ht by age & sex. Sample shows sex bias towards girls (127 boys, 198 girls).
Kenyan Turkana [o] 4-9 yrs	613	No nutritional classification	-	Not discussed	Settled children with institutional food support larger, and less variable, in most dimensions than nomadic children. No obvious sex differences.	2 cross-sectional surveys. Nomadic group (n=333) measured in rural camps, 1981-1984; settled group (n=280) measured while attending schools near an irrigation project, Jul 1984.
Kenyan Turkana [p] 0-2 yrs	239	No nutritional classification	-	Nomadic infants tended to be fatter during the wet season.	Settled infants slightly longer; nomadic infants heavier and fatter. No sex differences in either group.	Mixed longitudinal growth data collected May 1989 -July 1990

Sources for Table 2: a. Seaman *et al* 1973; b. Greene 1974; c. Benefice *et al* 1984; d. Loutan and Lamotte 1984; e. Wagenaar-Brouwer 1985; f. Hilderbrand 1985; g. Shell-Duncan 1995; h. Nestel 1986; i. McCabe *et al* 1989 cited Homewood and Rodgers 1991; j. Brainard 1990; k. Nathan *et al* 1996b; l. Hansen *et al* 1993; m. Lindtjorn 1987; n.Little *et al* 1983; o. Little and Gray 1990; p. Little *et al* 1993.

Note : Sources *a* through *f* used the Boston standards in assessment of low weight for height status; sources *g* through *m* used the NCHS/WHO reference populations; source *p* used the Waterlow classification.

lumping ages during analysis or focusing too narrowly on low weight-for-age, which may be highly prevalent at all times. It is therefore difficult to assess whether the data reflect population differences in the extent to which children are buffered by household adaptations to changing food availability. Few studies attempt to tease apart the independent effects of seasonal changes in morbidity and appetite from changes in food availability. One well-controlled study was able to show that large seasonal fluctuations in household food resources were only weakly associated with children's nutritional status, and highlighted the importance of generally high but temporally changing infection rates (Shell-Duncan 1995). Morbidity shows complex associations with ecological fluctuations in rainfall, temperature and resource availability, and is often statistically decoupled from seasonal cycles and has different nutritional consequences among adults and children (Tomkins 1993). What is certain is that the effects of seasonality may fall differentially on the various members of pastoral communities, and should therefore be investigated below the level of the household.

The cross-cultural data provide equivocal support for the hypothesis that growth faltering increases with the level of nomadism. Earlier studies tended to find a higher prevalence of indicators of child undernutrition among nomadic sections of pastoral populations. In contrast, more recent controlled comparisons among settled and non-settled communities within the same population suggest that in some circumstances nomadic children's health and anthropometric status is better. The first Turkana study found that young children on an irrigation project where government food supplementation had ceased had poorer nutritional status than nomadic children or children on supplemented irrigation projects (Brainard 1991). The second found that infants (0-2 years) from nomadic families were significantly fatter and heavier than those in a settled comparison group, although there was apparently no statistical control for differences in season of measurement between groups (Little et al 1993). Nathan et al (1996) have shown pastoral nomadic children children were significantly heavier, and attributed this to greater nutrient intakes during the drought in the form of camel's milk. Finally, Lindtjorn (1987) provided the first supporting evidence for the common anthropological assumption that pastoralist populations are buffered from nutritional deprivations during drought and famine conditions. Prevalence of low W/H and kwashiorkor during the Ethiopian famine were lower among pastoralist and agro-pastoralist communities than among agricultural communities, although subsistence type and geo-political location were strongly confounded.

Anthropometric status of adults

Anthropometric studies among a variety of African pastoral populations have yielded fairly consistent results. Table 3 compares some published estimates of anthropometric indicators for adults in population-based samples, and includes pooled mean values for groups of adults (originally stratified into 5-year age intervals; see Appendix A) in the African American sub-sample of the US NCHS reference data (Frisancho 1990).

Indicators of past nutritional status: stature. In all populations studied, mean adult heights were close to (not less than 97% of) the American value for both sexes. Less than half of the samples exceeded the American values, and among these the excess was no greater than 1% of reference height. There is therefore lit-

tle evidence in these data for the common assumption that African pastoralists are taller as adults than other populations, including Westerners in optimum environments. Indeed, there are no prevalence data with which to evaluate the hypothesis that stunting is not a problem among adult pastoralists.

Attention to the empirical data is important because the assumption of pastoral tallness may be unfounded. Rather, it may derive from an early focus on exceptionally tall individuals from some populations, who may not have been representative of the wider population or of African pastoralists in general. Reports of unusual tallness may have been exaggerated by the high cultural value many African pastoral societies place on tall stature and are keen to convey to outsiders, the height-accentuating effects of posture and body decoration, observations of generally low BMI's (slimness: see below) and direct comparisons to neighboring hunter-gatherer or horticultural groups (who are often stunted relative to international references). Additional evidence that African pastoralists do not on average acheive higher adult stature than reference populations comes from cross-sectional and mixed-longitudinal studies of the growth trajectory of nomadic Turkana (Little *et al* 1983, Little and Johnson 1987). Despite early growth deficits, Turkana males achieve equivalent adult stature to the reference sample of U.S. African Americans after relatively slower and prolonged growth during adolescence. Females achieve heights 2-5 cm less than the reference population, in part because puberty is less prolonged. I have recently found a similar pattern among semi-nomadic Datoga of Tanzania (Sellen n.d.). These data were not included in Table 3 due to differences in presentation.

Inferences about the growth perform-ance of pastoral populations by direct comparison of adult heights with reference data are complicated by several factors. First, it is possible that, even if individuals in pastoral populations do have a genetic potential for greater stature, few members of pastoral populations achieve it in full due to environmental constraints (such as an energy-deficient diet), so that equivalency of adult mean stature with references is not a valid indicator of adequate growth performance or nutritional status, and is not an indication of genetic potential. Second, since heights vary substantially among adults of different ages even within the same population, the age distribution of the samples may bias the results. Older surviving individuals tend to be shorter than younger ones, due the combined effects of skeletal aging, secular trends and, possibly, differential mortality by stature in the population (resulting in a up to a 5 cm difference between 18-25 and 70-75 year olds in the US: Frisancho 1990). Although age distributions are not reported for the samples included here, there is some possibility they were somewhat biased towards younger individuals. The Turkana sample reported by Little and Johnson (1987) does not suffer from this bias because the data are grouped by age even for adults; it is interesting that among men in their 40's, mean heights are a little greater than in the reference, suggesting differential survival of taller individuals.

The presumed tallness of African pastoralists has been used by some biological anthropologists to argue that these populations have different genetic propensities for growth. Although the population-level data force us to reject the hypothesis that pastoralists are on average taller than reference populations, it is significant that they are not much shorter. Given the evidence that

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Table 3. Mean anthropometric values for adults in various sub-Saharan African populations

Population (n)	Height (cm)	Weight (kg, seasonal ranges if available)	Mid Upper Arm Circumference (cm)	Triceps skinfold	Body Mass Index	Source
Men						
Turkana (40)	173.9 ±8.0	56.1 ±7.3	24.0 ±1.9	5.7 ±2.1	18.5 ±1.5	Galvin *et al* 1994
Borana (50)	169.9 ±6.1	54.7 ±6.8	23.4 ±1.9	4.9 ±1.4	19.0 ±1.7	Galvin *et al* 1994
Maasai (88)	171.2 ±6.5	57.6 ±7.9	-	-	19.7 ±2.5	McCabe *et al* 1989 cited Homer and Rodgers 1991
Wodaabe-Fulani Bororo (32)	176.3 ±5.24	58.4 ±7.5; 55.3 ±7.2	-	-	-	Loutan and Lamotte 1984
Fulani						Hilderbrand 1985
Rimaibe (20)	-	59.0; 56.5[‡]	-	-	-	
Fulbe (20)	-	54.8; 51.8[‡]	-	-	-	
Kel Tamasheq (?)	-	60.5; 57.7*	-	-	-	Wagenaar-Brouwer 1985
African Americans (US NCHS sample) [†]	174.2	77.6	25.6	11.1	32.4	Frisancho 1990
Women						
Turkana (42)	163.3 ±6.5	46.8 ±6.3	24.0 ±2.4	12.6 ±5.2	17.5 ±1.8	Galvin *et al* 1994
Borana (53)	159.1 ±6.0	47.5 ±6.4	22.8 ±8.2	10.9 ±3.4	18.5 ±1.5	Galvin *et al* 1994
Maasai (180)	159.9 ±5.5	49.1 ±6.6	-	-	-	McCabe *et al* 1989 cited Homer and Rodgers 1991
Datoga (216)	158.8 ±6.2	47.5 ±7.1; 46.4 ±7.0	23.7 ±2.5	10.2 ±3.9; 7.8 ±2.7	18.8 ±2.5	Sellen 1995
Wodaabe-Bororo (30)	164.6 ±6.8	49.9 ±8.3; 52.3 ±8.9	-	-	-	Loutan and Lamotte 1984
Fulani						Hilderbrand 1985
Rimaibe (20)	-	54.8; 52.9	-	-	-	
Fulbe (19)	-	55.0; 47.5	-	-	-	
Kel Tamasheq (?)	-	59.9; 58.7*	-	-	-	Wagenaar-Brouwer 1985
African Americans (NCHS sample) [†]	161.5	72.9	31.9	25.8	27.9	Frisancho 1990

Legend to Table 3.

Notes: SD's shown when reported

[†] Values shown were taken from Appendix A, in which a single mean value for African American men and women aged 18-74.9 is calculated from the means of 5 year age intervals into which Frisancho (1990) stratifies the NHANES I and NHANES II samples.

*Means were reported for two different social classes in two different camps; overall means have been calculated here

‡Values estimated from original graphs by interpolation

growth retardation is common in childhood and nutrient intakes are probably too low in these populations, the challenge is to understand the processes by which adult stature (particularly of men) comes to approximate that of the references, and to understand the factors producing variance in stature within and between populations. It is possible that genetic factors contribute to a delayed or extended puberty allowing for more catch-up growth during adolescence (Martorell *et al* 1994, Sellen n.d.), but more research is needed to tease apart genetic, dietary and other environmental influences.

Recent nutritional status: weight and body composition. In contrast to heights, adult weights are markedly lower than the reference among all the pastoral populations studied and are associated with very low BMI values. At between 67-78% of the US male, and 64-82% of the US female, references for adult weight. Two lines of evidence suggest these anthropometric data reflect a high incidence of undernutrition among the groups sampled. First, although population average BMI's lie at or above the threshold defined as indicating some grade of chronic energy deficiency (i.e. BMI 18.5: James *et al* 1988) for all but one population (the Turkana of northern Kenya), attention to the reported standard deviations indicates that between one third and one half of all adults in the samples were at risk of chronic energy deficiency at some level (although no published estimates of BMR are available to control for possible variations in energy requirement). Second, these cross-cultural weight data can help in the interpretation of the cross-cultural dietary intake data described above. The lowest average body weights of men and women across all published studies (i.e. taking seasonal minima), are 55.7 and 50.3 kg respectively. Combining these weights with the estimates of per kilo energetic expenditures for moderately active men and women in the most recent US Recommended Dietary Allowances (National Research Council 1989), yields conservative estimates of daily energy requirements of 2,284 and 1,861 kcals/person/day for sub-Saharan African pastoral men and women respectively. Thus, the estimated average annual energy intakes of people in these populations apparently fall below these estimated requirements by perhaps up to 40%.

Given that the low weights are in themselves almost certainly a response to prior chronic food shortage, the fact that intakes may not be sufficient to sustain even these smaller bodies is significant. The true magnitude of the shortfall for adults is difficult to evaluate because the published studies include children's consumption in estimates of dietary intakes, but are not clear as to whether these are adjusted to adult equivalent intakes in presenting population averages. There are also strong arguments against the use of estimates of energy requirements derived from studies of western populations, which may not be appropriate if poorly understood energy sparing mechanisms are occuring in nutritionally challenged populations (James and Shetty 1982, Prentice 1984, Widdowson 1985, Waterlow 1986, Martorell 1989, Pelto and Pelto 1989, James *et al* 1990, Waterlow 1990). Nevertheless, true average population requirements may be much higher among pastoralists if activity levels are heavy or exceptional, and where disease, parasitic infections and other environmental factors increase metabolism or decrease assimilation efficiency.

There are few data on weight variation within populations. Seasonality is widely regarded as presenting a special difficulty in the study of pastoralists

(Dyson-Hudson and Dyson-Hudson 1981, Hill and Randall 1985). Seasonal changes are expected to have important effects on subsistence practices, food intake and nutritional status of many rural populations in the developing world (Ferro-Luzzi 1990a), and could greatly influence point estimates of nutritional status from single surveys. However, while there is strong consensus that pastoralists must be particularly at risk during seasonal deprivations (Little *et al* 1983, Little 1989, Nestel 1989, White 1991), the empirical evidence for effects among adults remains scant. Adult weights do show appreciable seasonal fluctuations (of the order of 5% of maximal body weights) for both sexes in most of the studies where seasonal comparisons were made (Loutan and Lamotte 1984, Hilderbrand 1985, Wagenaar-Brouwer 1985). In one study adult men generally showed greater absolute, and sometimes relative, fluctuations in mean body weights than adult women (White 1986). However, another study documented only minor seasonal changes in a battery of indicators of nutritional status among adults (Benefice, Chevassus-Agnes, and Barral 1984).

Two further points emerge. First, in the two samples where marked sociocultural class differences existed within the population (Hilderbrand 195), there were indications that adults in the dominant classes had higher body weights. Second, the intra-populational variances in weight are much less than those in the reference population (always less than 10 kg among adult pastoralists of all ages versus between 15-20 kg even within 5 year age groupings in the US). Thus, both seasonal and socioeconomic effects on body weights are indicated in the comparative data. Nevertheless, the magnitude of *within*-population differences is not great, and is not particularly greater among men than women, in con-

trast to what has been observed in rural agricultural African populations. Maximum differences in mean weights among the pastoral groups studied were approximately 5.5 kg for men and 10 kg for women, indicating important differences in the nutritional situation in each. However, the data are too few to recognize any ethnic, sociocultural or geographic pattern to this apparent variation among groups.

Both arm circumferences and triceps skinfolds were lower than references in all populations studied, with women showing larger deficits in total arm circumference than men, probably due to reduced muscle mass as well as fat (but see Little and Johnson 1986 for a description of the opposite trend in a sample of Turkana). Both sexes had only about 50% of the skinfold thickness of their US counterparts, indicating much lower body fat reserves in both sexes. It is difficult to assess the magnitude and causes of within-population variance in body composition from these data, since the nutritional effects of sex differences in work and reproductive activities, season, age, and various socio-cultural factors have not generally been investigated. The single study in which such effects were investigated found that, among women, sedentarisation was associated with decreased body weights, both body mass and skinfold thicknesses decreased with age, and parity was negatively associated with fat stores after controlling for age (Little *et al* 1992).

Biochemical and clinical assessment

Prevalences of anemia and deficiencies of iron, zinc, vitamin A, riboflavin and other micronutrients are unknown for most African pastoralist populations. Only a handful of studies provide estimates of the prevalence of specific micronutrient deficiencies based on biochemical assay or clinical symptoms. A

few of these have failed to find strong correlations between low nutrient intakes and typical nutritional deficiency diseases.

Rates of anemia among children under 6 years of age are high in both nomadic and settled Rendille communities in Kenya (Nathan et al 1996), and mean hemoglobin values are lower for settled children (9.47 mg/dl versus 10.83 mg/dl). Additional data on morbidity and diet suggest the difference could be due to both lower rates of malaria and higher intakes of iron from camel's milk among nomadic children, although serum ferritin levels were not obtained to distinguish iron-deficiency from parasite-induced hemolysis. Vitamin A deficiency is a major nutritional problem among young children in Ethiopia, with the highest rates of Bitot's spots and low serum retinol levels occurring among children of pastoralists versus subsistence cultivators and cash croppers (Wolde-Gabriel et al 1991). Although vitamin A deficiency was attributed at the national level to low intakes of pro-vitamin-A-rich vegetables and fruits stemming from a combination of economic, ecological and cultural factors, the high prevalence among populations consuming meat and dairy products was also an indication that retinol levels in these foods are low.

Among the Maasai, where intakes of iron and vitamin C intakes are lower than recommended (Nestel and Geissler 1986) almost no clinical indications of vitamin C deficiency could be found, and anemia was recorded only among young children and pregnant and lactating women. Earlier studies also revealed little evidence of anemia and adequate vitamin C (Gatenby-Davies and Newson 1974). Similarly, although indications of general protein-energy malnutrition were found in 10% of children of Senegalese pastoralists (Benefice et al 1984),

very few clinical indications of micronutrient deficiencies were found in any age group. The same was true of Turkana pastoralists settled on an irrigation scheme (Brainard 1990). Although these reports all conclude that indications of nutrient deficiency were not prevalent, it would be unwise to assume this is true for the majority of African pastoralists based on such a small number of studies.

There are few reports of nutritional diseases due to overconsumption and inactivity, as might be expected given generally low caloric intakes and active lifestyles. Certain east African pastoralists show generally low levels of plasma lipids in comparison to western references, and low rates of cardiovascular disease despite reportedly high fat and cholesterol consumption (Shaper et al 1961, Biss et al 1971, Davies and Newson 1974, Mann 1977). However, it is possible that the annual and lifetime consumption of meat and milk products was overestimated in these studies because of an overemphasis on food consumption by certain age and gender groups at certain times. This apparent paradox should be reexamined in the light of the intake data discussed above.

Sampling bias during surveys

The inadequacy of much of the data reviewed is evidence that sampling biases are a major problem in anthropometric surveys of African pastoralists. Within studies, field personnel are usually confronted by low population densities, poorly accessible landscapes, frequent movements of the populations under study and frequent rearrangements of social groupings. Gaining access to the subjects, and then tracking identities, births and deaths demands increasing expenditures of time and resources in direct proportion to the degree of nomadism and the complexity of social

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relations at the local level (Bernus 1988). Under these constraints, conclusions must be drawn from much smaller achieved sample sizes (rarely exceeding 500 children) than are usual for most epidemiological studies.

When attempting to survey pastoral children, it appears that in several of the published studies more females than males were measured and that teenagers, especially males, were less likely to be measured (see, for example, comments on this problem in (Little and Johnson 1987). Such sampling biases may stem from sex differences in work activities which limit the opportunities for surveillance. In most pastoral societies the home-based activities of female children contrast with the herding activities of male children which take them far from the household for much of the time, especially as the children get older. This may be one reason why sex differences in the nutritional status of children of African pastoralists have not been a major focus of research attention, even though marked sex differences in work activities (Fratkin 1989), eating patterns (Nestel 1985), childcare and inheritance practices (Cronk 1989), and the stated preference for offspring of one particular sex have been observed in several pastoral cultures (see Sieff 1990 for a more general review). However, there is little evidence for differential mortality by sex in pastoralists (Borgerhoff Mulder 1989, Borgerhoff Mulder 1991; but see Pennington and Harpending 1993, Chapter 3, for an important exception).

Where longitudinal surveys are attempted, logistic problems often result in a failure to follow up on many of the individuals in the initial samples (multiple measures over time were made on less than 12% of children in the studies in Table 2). This may limit the internal validity of inferences drawn from the uncensored data. It may also be very difficult to generate an adequately stratified cross-section of measures on different individuals within short time periods. This makes it very difficult to examine or control for temporal changes affecting the data. In practice, estimates of standing prevalences of indicators of undernutrition and assessments of longitudinal variation have often combined both multiple measures on the same individuals over time and single measures on rarely encountered individuals. Possible biases introduced by the "mixed-cross-sectional" approach are rarely discussed, but will be equivalent to combining the problems of a cohort study carried out without censoring with those of a cross-sectional study carried out during an ongoing temporal trend (Cummings et al 1988, Newman et al 1988). In addition, samples may become weighted towards larger, more accessible, more cooperative or less mobile families or groupings, skewing results in unknown ways.

The assumption has often been made that African pastoralists form societies which are homogenous with respect to wealth and access to food and health care, but this assumption is clearly incorrect (Herren 1990). If there is any possibility that socioeconomic differences within a pastoral population are correlated with outcome measures of nutritional status (Little 1985), and whenever differences in settlement or market utilisation translate directly into differences in nutritional status (Little et al 1992, Leslie et al 1993), then biases in the sampling of households may influence conclusions about a whole population. In fact, it is clear that these possibilities have not yet been fully examined for any group.

While a compromise between validity and practical constraints can always be reached (Greenberg 1993), the problems of sample bias must always be care-

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fully addressed. The recent debate over whether within-population variability in anthropometric measures increases with greater levels of environmental stress, especially among children (Stinson 1985, Schmitt and Harrison 1988, Harrison and Schmitt 1989, Bogin 1991, Dettwyler 1992) also strengthens the case for careful sampling strategies when assessing pastoralists living in harsh environments. Only the Kenyan Masaai, Turkana and Rendille studies made any stated attempt to avoid biases in sampling of the kind outlined above. Therefore, sampling biases cannot be excluded as possible influences on the reported patterns.

Conclusions and suggestions for future research and nutritional interventions

This review of literature suggests that African pastoralists continue to be neglected in comparison to agriculturalists during nutritional surveys in arid regions. Despite the large size of sub-Saharan pastoral populations and their wide distribution across nations, reliable information on food consumption and nutritional status has been obtained for only a handful. Previous reviewers have despaired of the extreme paucity of data on the nutrition of savanna peoples generally (Wheeler 1980: 443). The comparative analysis of nutritional status among African pastoral populations is also made difficult by lack of data, possible sampling biases, differences in the conditions and methodology of data collection, and substantial ethnic, socioeconomic and regional diversity in the samples from which published data are drawn.

Although the diversity of modern African pastoral systems limits the value of general conclusions, some broad patterns emerge. Studies of diet composition, seasonal variability and total caloric adequacy suggest marked seasonal differences in dietary composition and total intakes (lowest in the dry seasons) are the norm. Total per capita caloric intakes are uniformly low relative to global recommendations. Micronutrient intakes are often insufficient. Anthropometric data indicate that while seasonal effects on body size and composition may be weaker than might be expected, a large proportion of the children and most of the adults in African pastoralist populations fall below anthropometric reference data on weight and weight-for-height. This strongly suggests that the generally low food intakes reported for African pastoralists do play a significant role in producing growth deficits which persist into adulthood.

However, more data are needed before we can draw a firm conclusion that scarcity of food contributes to reduced growth among African pastoralists. Wherever low nutritional status has been reported for African pastoralists, the magnitude and causes of intra-population variation in growth faltering were not well evaluated. Specific mechanisms for the etiology of undernutrition remain unclear. More data on dietary quality and more longitudinal observational studies of child growth and its relation to a variety of possible causal factors are needed. There is evidence that low energy and protein intakes may not be the prime cause of growth faltering and marginal undernutrition in all populations. The importance of infection in the etiology of undernutrition and seasonal fluctuations in nutritional status remains poorly evaluated despite very early interest by human biologists. Disease ecology and socio-economic disadvantages will interact with diet to produce undernutrition.

The role of milk, fat and meat in buffering individuals against growth stunting or promoting catch-up growth has never been properly evaluated. Recent multicentre studies on non-pastoralists indicate that dietary quality is more limiting for child growth than quantity. High quality diets contain adequate vitamin and mineral content and high bioavailability of these nutrients. Controlling for socio-economic status, children whose diets contain more animal products had better growth and superior performance on cognitive and behavioral tests than did children whose diets were based largely on cereals and legumes (Allen 1994). This review suggests that milk rather than meat will be the critical source of micronutrients among most African pastoralists. In fact, most of the studies in which intakes of micronutrient were assessed found that one or more was deficient in the diet. We need to examine the possible impact of micronutrient deficiencies on growth and nutritional status.

The cross-cultural associations between age, sex, seasonality and residence patterns on nutritional indicators suggest that growth deficits begin early in life, show few sex differences, and vary inconsistently by season and settlement. The role of catch-up growth during middle and late childhood in producing adult heights close to reference values needs more investigation. A present lack of data on stunting prevalence among adults and other functional indicators precludes us from testing the hypothesis that early growth deficits are compensated later in life, either through cultural adaptations influencing diet or activity, and/or through genetic adaptations. Seasonal effects almost certainly involve the interaction of infection and nutritional intake, which will vary across settings. Other local factors, such as initial wealth differentials and availability and adequacy of food aid, will also condition the effects of settlement on diet, energy expenditure and health. These are some indications of positive associations between wealth and nutritional status or adequacy of household food supply within populations, but the nutritional importance of wealth differentials deserves more investigation.

Future studies must be carefully designed so as to overcome the field logistical problems which have led to unacceptable levels of sample bias in previous studies of nutritional status. At present, sampling biases due to problems of poor accessibility make it difficult to assess to what extent reported patterns are due to the living conditions of African pastoralists *per se* or are artifacts of inadequate study design. Many pastoralists live in marginal areas unsuited to agriculture or permanent settlement. Often they are geographically and culturally isolated, with a limited participation in the cash economy; access to primary health care and participation in rural development programs are also severely limited. Such conditions work to create a specific set of logistic and ethnographic problems commonly encountered when attempting to assess the nutritional situation among African pastoralists. There is a need to design studies which can overcome methodological problems as efficiently as possible.

In sum, only vague clues emerge as to the underlying factors producing the large apparent differences in nutritional status among pastoral populations because of the paucity and inadequacy of the data. There is an extreme paucity of data on micronutrient intakes, micronutrient status and deficiency diseases. Anthropometric indicators, especially for children, and data on intakes of energy and some micronutrients suggest nutritional problems are widespread.

These populations subsist on extremely low energy intakes, and both adults and children are of very low average body weight. Several studies indicate deficiencies of vitamin A, C, iron and calcium occur for some populations at least some of the time. Coversely, data on nutrient deficiency disorders, intakes of protein, and on stature of adults suggest successful adaptation to nutritional challenges. Adult stature compares favorably with international references, although sampling problems make it impossible to interpret this result as due to. Sex differences in nutritional status are minor. Undernutrition may be related to factors other than dietary quantity and quality. Data on seasonal and socioeconomic variation suggest the importance of infection and of differential access to food by wealth as causal factors in childhood malnutrition, but indicate the need for more research in to the nutritional implications of disease ecology and wealth differentials. If we are to throw light on the precise links between food supply and nutritional status we must continue to refine our analyses with measures of local socio-ecological conditions, and to collect data on a diversity of pastoral populations.

Acknowledgements

Appendix A

Mean values of anthropometric indicators for a sample of African American women aged 18-74.9 years.

INDICATOR	MEAN (18-74.9 years)	RANGE (of 5-year interval means)	Typical S.D. of interval means
Height	161.5	158.4-162.6	6
Weight	72.9	63.2-78.7	20
BMI	27.9	23.9-30.4	7
MUAC	31.9	28-34.2	6
Triceps SF	25.8	19.3-29.5	10.5
Subscapular SF	25.6	17.6-30.7	12
UMA	39.2 (+6.5 adjustment)	32.3-43.4	12
UFA	33.9	25.2-44.0	20
AFI	42.6	37-41.8	11

Data calculated from the tables in Frisancho (1990), based on NHANES I and II, in which the sample was stratified into 5 year age intervals. The means across age intervals presented above can be used for comparing populations of adult women which cannot be dissagregated by age.

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Resumé

Cette étude fait le sommaire des connais-
sances actuelles sur les problèmes ali-
mentaires des nomads pasteurs africains.
L'auteur constate que les données sur la
nutrition et l'état nutritionel dont nous
disposons aujourd'hui sont insuffisantes
et de qualité variable. Il montre que cer-
tains problèmes particuliers ont été mal
compris: Les apports variables des pro-
duits laitiers riches en minerals et vitami-
nes à l'alimentation pastorale; la façon
selon laquelle ces micronutrients favori-
sent la croissance; l'importance du fait
que le retard de croissance dans la pre-
mière enfance peut se rattraper par la
suite; et enfin, l'étiologie de la maladie et
de la pauvreté.

Resumen

El trabajo resume los conocimientos ac-
tuales sobre los problemas nutricionales
a los que se ven enfrentados poblaciones
pastoriles africanas. Los datos sobre el
consumo de alimentos y el status nutri-
cional son escasos y de calidad muy va-
riada. Algunos temas muy poco entendi-
dos hasta ahora son la conribución varia-
da de productos lácteos ricos en micro-
nutrientes en dietas de pastores, el rol
desconocido de micro-nutrientes para el
crecimiento, la importancia de la recupe-
ración del crecimiento durante la infan-
cia tardía y la etiología de enfermedades
y del empobrecimiento.

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