

**Sedentarization, Seasonality, and Economic Differentiation: Maternal Diet and
Health in Ariaal-Rendille Communities in Northern Kenya**

by


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ABSTRACT

This thesis examines the impact of the recent transition from nomadic pastoralism to sedentism and concomitant economic differentiation upon seasonal patterns in maternal diet, morbidity, and anthropometry made by Ariaal and Rendille peoples in northern Kenya. Results reveal clear differences between the dietary patterns of nomadic and sedentary mothers. The reduction of dietary protein, the increase in dietary energy, and the alleviation of seasonal dietary stress affected sedentary mothers' body compositions such that their body fat and protein stores fluctuated in a distinct manner each from the other. Morbidity patterns of sedentary mothers reflected neither the dietary seasonality nor the seasonal patterns of rainfall, both of which were important determinants of nomadic mothers' health statuses. The results demonstrate the importance of longitudinal research design in studying and understanding the consequences of sedentarization.

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Chapter 1

Introduction

1.1 The Purpose of the Study

This thesis examines the impact of sedentarization upon seasonal patterns in maternal diet, morbidity, and anthropometry, associated with the transition from nomadic pastoralism to sedentary agriculture on Ariaal and Rendille peoples in northern Kenya.

The thesis begins with a brief discussion of the purpose, problem and framework for this study. This is followed by a review of ethnographic information on the Ariaal and Rendille and historical backgrounds for their sedentarization. In order to situate the problem in wider contexts, more general nutrition studies are reviewed, as they relate to the potential dietary changes associated with sedentarization. In the focal section, the thesis presents comparative statistical data analyses of two Ariaal and Rendille communities: Lewogoso, a subsistence-oriented nomadic pastoral community of Ariaal people who continue their highly seasonal and mobile lifestyle (Fratkin 1998: 89-98); and Songa, an irrigation agricultural community of former pastoralists who grow a substantial amount of their agricultural produce for market sale, and spend their cash income to purchase the bulk of their diet (Smith 1997). In the final section, the thesis discusses the implications of the results.

The purpose of this thesis is two-fold. First, it is to understand the consequences of sedentarization on maternal diet and health, and how these factors may intersect with seasonality and economic status. Little is known about the consequences of sedentarization on diet and health, and their interaction with seasonality (Huss-Ashmore 1993) and economic status. Similarly, research on these effects specifically as they relate to adult women is still limited (a rare example is Nestel 1986).

Second, it is to contribute to a three-year parent project, entitled *the Rendille Sedentarization Project*. Both the thesis study and parent project were supervised by Dr. Eric A. Roth, Department of Anthropology, University of Victoria, British Columbia, Canada. The parent project is a joint collaboration of Dr. Elliot Fratkin (Smith College, Northampton, Massachusetts, U.S.A.), Dr. Martha Nathan (Medical Practitioner, Community Health Center, Springfield, Massachusetts, U.S.A.), and Dr. Roth. The aim of the parent project is to examine the bio-social concomitants of sedentism of sub-Saharan pastoralists, specifically on child-growth and maternal health in five Ariaal and Rendille communities: one nomadic community of Lewogoso and four now sedentary communities of Karare, Korr, Ngurunit, and Songa. This parent project has already produced several publications (Fratkin et al. 1999a, 1999b; Nathan et al. 1996), mainly focusing upon changes in child-growth patterns, details of which will be mentioned in the following chapter. This thesis is the first extensive analysis of Ariaal and Rendille mothers' diet and health which uses a small portion of the data-sets, covering the two communities for a one year period with the typical bimodal rainfall pattern, characteristic of East Africa. The findings in this thesis therefore constitute part of a longer-term, larger-scale study, orchestrated to achieve a better understanding of the nutrition and health of pastoralists and former pastoralists of northern Kenya.

1.2 The Problem: Dietary and Health Consequences of Sedentarization

Ariaal and Rendille nomadic pastoralists of northern Kenya have adapted to conditions of large seasonal variations in rainfall which markedly affect food availability and health. These peoples are becoming increasingly sedentary mainly as a result of drought-induced livestock loss in the 1970s (Fratkin 1991, 1998; Fratkin and Roth 1990;

Fratkin et al. 1999a, 1999b; Smith 1997).

Sedentarization entails not just a simple loss of mobility but a transition from a pastoral to an alternative economy. The consequences of this economic transition can and ought to be measured in several ways, using a variety of variables ranging from monetary units such as cash income to physical units such as nutritional status, particularly when such a transition entails a shift from subsistence-oriented economy to market-oriented economy (Dewey 1981; Mebrahtu et al. 1995; Roth 1994).

In order to assess the adaptive success of an economic transition, however, it is crucial to examine the new economy's "ability to provide adequate nutrients and other resources during the lean season, while not jeopardizing health, biological function, or long-term productive capacity" (Huss-Ashmore 1993: 202, 215). This thesis therefore pays close attention to the seasonal aspects of dietary and health consequences of sedentarization.

Pastoral diets generally can be characterized as a high-protein diet but with marked seasonal variation in both protein and energy content (Fratkin et al. 1999a: 731; Galvin 1985, 1992; Galvin and Little 1999: 125; Hilderbrand 1985; Little et al. 1993; Nathan et al. 1996; Nestel 1986; Shell-Duncan 1995). The milk-based, high-protein diet of pastoralists appears to positively contribute to their adaptation to a highly seasonal environment with limited resources for dietary energy (Galvin and Little 1999: 144-145).

The lean season for nomadic Ariaal and Rendille pastoralists is during the dry season when edible pasture for livestock becomes scarce, which in turn limits both drinking water and milk availability for human consumption (Fratkin 1991: 31). In such times, pastoralists attempt to maintain their food supply by supplementing their diet with grains, which provide dietary energy (Galvin et al. 1994; Nathan et al. 1996). Among the

Ariaal and Rendille, men may ease their hunger by consuming their herds' blood and meat. Food norms however, preclude women from consuming these items (Fratkin 1998: 85), making them depend more upon grains hence more carbohydrates. Despite such seasonal stresses, the ramification of a seasonal high-protein diet of pastoralists may be particularly significant for infants, pregnant women and lactating mothers. These three groups not only are "vulnerable groups ... at risk from poor environments" (Panter-Brick 1997: 66), but also have elevated requirements for dietary protein (Foster 1992: 83).

Permanent settlements may provide more stable access to vital resources such as food and water, alleviating the seasonal stresses that long dictated Ariaal and Rendille's lives. Towns offer amenities such as a permanent water supply, medical services and shops (Fratkin 1991: 122). Town life also provides people with better access to education (Fratkin and Smith 1995: 450), jobs and entrepreneurship (Smith 1997: 35-36). For example, the number of youths who pursue a post-secondary education has grown, enabling some Ariaal and Rendille people to find employment with government services (Fratkin 1991: 123). Women may benefit from "the reduction of drudgerous [sic] or dangerous tasks [such as] water collection or livestock herding" (Fratkin and Smith 1995: 450).

Although one could assume that settlement with such amenities and opportunities may produce better diet and health, studies often refute this simplistic assumption (Campbell et al. 1999: 352; Fratkin et al. 1999a, 1999b; Nathan et al. 1996). For example, archaeological and paleopathological studies associate sedentism with negative effects on the biological status of a human population (Bodley 1990; Goodman and Armelagos 1985). Increased morbidity and mortality, particularly during sedentism's initial periods, due to increased exposure to various disease vectors (Huss-Ashmore

1993: 213, 215) or the modified dietary practices (Goodman and Armelagos 1985) have been found. For contemporary East African pastoralists, Campbell et al. (1999: 347-349) report negative biological consequences of modern sedentism on adult members of Turkana, another pastoral group of northern Kenya, including shorter stature and poorer nutritional status when deprived of relief supplements, and increased morbidity.

When nomadic pastoralists switch to a more market oriented agricultural economy, they may experience a deterioration of their nutritional and health statuses (Bodley 1990), associated with the shift from the protein-rich pastoral diet to the more cereal-based diet. Since protein is an indispensable nutrient for reproductively active pastoral women as well as for children (Galvin and Little 1999: 144-145), the potential protein loss associated with agricultural sedentism has serious ramifications on maternal diet and health.

Conversely, a group's nutrition may potentially improve when store-bought foods are combined with subsistence production to provide the stability of food supply while maintaining the nutritional value (Fratkin et al. 1999a). Irrigation agriculture may actualize such an ideal situation with both dietary stability and nutritional balance at the same time, provided that a wide variety of plant crops are grown and consumed by the community. In their large-scale cross-sectional study of food frequency data, Shell-Duncan (2000: 11) and Shell-Duncan et al. (2001: 31) found that settlement and development in highland Rendille communities, including Songa, resulted in an improved energy, macronutrient, and micronutrient intakes.

Moreover, the severity of dietary stress may depend upon the wealth status of the family. Major shifts in production systems may simultaneously improve and deteriorate the nutritional status of a community, in which socioeconomic status may

determine whether one benefits or suffers (Popkin et al. 1993). In a nomadic pastoral community, the health risk would be more serious when the family's resource base is limited, having few animals to trade for grain at times of need. Such families may be the ones who first experience the seasonal or drought-invoked nutritional stress. Nonetheless, nomadic pastoral families actively engage in reciprocity and exchange, potentially minimizing the differences in dietary patterns by wealth status (Fratkin, personal communication). When nomads settle, however, along with the transition from a subsistence economy to a more market-oriented economy, wealth differences among families may be emphasized, potentially weakening the reciprocal distributive mechanism of the seasonal food scarcity (Fratkin, personal communication). Such wealth differentiation can be seen in the vertical relationships involving absentee herd owners among former Il Chamus pastoralists of northern Kenya. Through settlement schemes in the 1950's, some former pastoralists who individually succeeded as businessmen and local retailers, had acquired livestock purely for investment purposes and hired local herders to look after their animals (Little 1985: 144-5). Such an individualistic "success story" is a clear departure from the reciprocity-oriented economy of the pastoral sector.

In an agro-pastoral community wealthy families may have a wider economic resource base, encompassing both pastoralism and agriculture (Fratkin 1998). This allows them not only to alleviate seasonal fluctuation of food availability but also to widen the variety of food in their diet. Poor families, in contrast, may rely solely on their agricultural harvest for their subsistence and cash income. If their family plot is not large or productive enough, or if their crop fails due to the unexpected rain patterns or insect infestations, they may have no choice but to depend upon aid from their friends or relatives or relief food from governments, private donors, and/or international aid

programs for their survival (Smith 1997: 101).

Likewise, among sedentarized Ariaal and Rendille women, the degree of integration to town markets depends upon their household economic status (Fratkin and Smith 1995: 450). Those who own sufficiently productive resources, for example, can sell surplus milk or vegetables to regular customers in town, whereas the poor without such resources cannot. By implication, wealthier women may be more successful in obtaining the stability of both food intake and nutritional quality. Shell-Duncan et al. (2001: 30) have documented such cases of intra-community discrepancy among Rendille women in highland settlements where sedentism and development resulted “not only in overall improvements in dietary intake, but also increased disparity in economic status and risk of low dietary intake of milk, a key staple food.”

In addition, there are contrasting seasonal patterns of nutritional stress between agriculturists and pastoralists. Critical periods for agriculturists coincide with the food shortage and high labor demand associated with farming and harvesting during the pre-harvesting time (Simondon et al. 1993: 166). Poorer families who have little access to pastoral resources to supplement this stress may therefore potentially experience seasonal stresses distinct from those of wealthier families.

1.3 Conceptual Framework

To systematically assess the potential effects of sedentarization and seasonality upon Ariaal and Rendille communities, a conceptual framework similar to that suggested by Huss-Ashmore (1993: 214-215) was adopted. Variables are summarized into three interdependent groups, which connect agricultural sedentarization to seasonality and biological outcomes (Table 1). Each of these three groups are classified as distal,

intermediate, and final variables respectively.

Table 1-1: Three Groups of Variables

Distal Variables	Intermediate Variables	Final Variables
Pastoralism (Lewogoso) vs. Agriculture (Songa)	<u>Nutritional and Health Seasonal Factors:</u> Dietary Intake, Nutrient Requirement, Pathogen Exposure <u>Socioeconomic Seasonal Factors:</u> Economic Status, Cash Access	<u>Biological Outcome:</u> Anthropometry & Morbidity

The distal group includes the dichotomous variable of economy (or community): nomadic pastoralism vs. sedentary agriculture. The intermediate group constitutes a broad range of social, economic, and environmental variables that immediately affect the people's biological status. However, this study focuses on two main factors: nutritional/health and economic variables in order to make the study manageable as a Master's thesis. These nutritional/health factors include dietary consumption, nutrient requirements, and pathogen exposure, all of which are influenced by seasonal patterns of resource availability. Economic factors such as differential access to wealth and productive resources also influence the biological reality of the people by affecting the way in which they experience the food scarcity. The final variables are the realized results of biological outcomes, which can be assessed in terms of the biological variables of anthropometric measurements and morbidity episodes.

With aid of this framework, this thesis will statistically examine the impact of sedentarization upon the seasonal patterns in maternal dietary intakes, morbidity episodes, and anthropometric measurements in two Ariaal and Rendille communities.

This chapter outlined the purpose, problem and framework of this thesis. Chapter 2 presents a review of ethnographic information of Ariaal and Rendille peoples, the historical contexts toward their sedentarization, and the previous findings from the *Rendille Sedentarization Project*. Chapter 3 is a literature review of the significance of dietary protein, a nutrient, the accessibility to which is likely to change with agricultural sedentarization, and which potentially dictate Ariaal and Rendille mothers' health. This sets the stage for Chapter 4 which generates hypotheses and explains the materials and methods used in the data analysis. Chapter 5 and 6 present the data analyses and results. The former focuses on the bivariate descriptive statistical analysis in order to describe the seasonal trends in each of several key variables as well as to understand the effect of lactation status. The latter chapter focuses on the multivariate inferential analysis, in order to understand the interrelationships and interactions among different variables including economic status. Chapter 7 discusses the implications of the findings, as well as brief recommendations for further research.

Chapter 2

Ariaal and Rendille: from Pastoralism to Sedentarization

This chapter begins with a review of the ethnographic information on Ariaal and Rendille nomadic pastoralists, along with specific examples from a nomadic pastoral community of Lewogoso. This introduces the reader to the Ariaal and Rendille's nomadic pastoral adaptation, ecological settings, ethnic identities, labour organization, and dietary characteristics. It then reviews historical materials to delineate the trend toward sedentism, followed by the ethnographic examples from Songa, an irrigation agricultural community of Rendille former pastoralists, in order to illustrate the social and cultural changes that accompanied agricultural sedentarization. The chapter concludes with a review of previous findings of dietary and health consequences of sedentarization on Ariaal and Rendille children, from the *Rendille Sedentarization Project*, the parent project for this thesis study.

2.1 Ariaal and Rendille: Peoples and Setting

2.1.1 Nomadic Pastoral Adaptation, Ecological Setting, and Seasonality

Nomadic pastoralism – the herding livestock of camel, cattle, and small stock such as goats and sheep with high seasonal mobility – has been the effective long-term sustainable adaptation of the Ariaal and Rendille, which allowed them to make the best use out of their violently seasonal and arid environment (Fratkin 1991, 1998). Northern Kenya is extremely arid with an average annual rainfall of less than 500 mm. The location, quantity and timing of the rainfall are unpredictable throughout the region (Fratkin 1991:

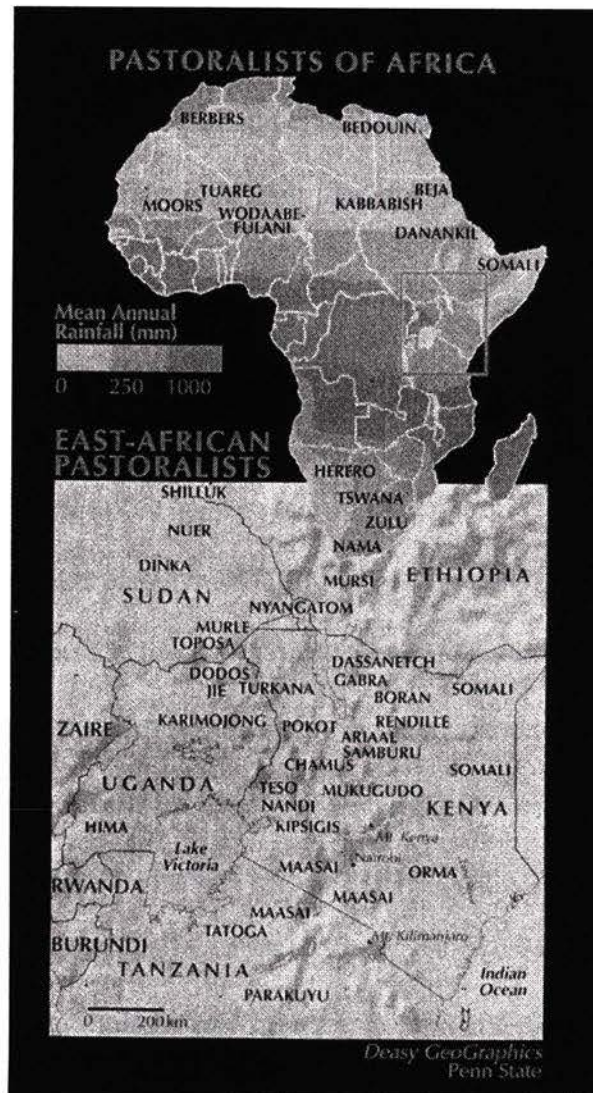
39). Low-lying areas are deserts with an annual rainfall of less than 200 mm. Highlands such as Mt. Marsabit may enjoy over 1,000 mm of annual rainfall. When it rains, water may be available from various sources of surface water such as rock pools, mud-flats, and springs, as well as from minor streams which may run for “anything from a few hours to a few days” (Sobania 1988: 222). However, in this arid land, water does not stay on the ground very long. The major portion of rainwater is absorbed into the ground. Thus to ensure a more long-term access to water, one generally has to dig in dried river-beds or places with underground rock pools although such sources too are subject to highly seasonal fluctuations associated with rainfall patterns (Sobania 1988: 222).

The area is also prone to prolonged droughts. For example, extensive droughts during the last three decades include the ones that occurred in 1968-73, 1983-84, 1992, and 1996 (Fratkin et al. 1999a: 729). This isolated and underdeveloped arid land has nonetheless provided homes for several other nomadic pastoral groups, including the Turkana, Samburu, Boran, Gabra, and Somali (Fratkin 1998: 2). Figure 2-1 is a map of the distribution of East African pastoral peoples, including the above mentioned groups in the Lake Turkana and surrounding region.

Typical of East Africa, the area has four seasons in a normal year. Two rainy seasons consist of a “long rain” between March and May and a “short rain” between October and November. The two rainy seasons are punctuated by two dry spells. These dry seasons are, in the local language of the Ariaal and Rendille, literally expressed as the time of “hunger.” The *lamai lo’odo* or “long hunger” is the dry period between November and March while the *lamai dorrop* or “short hunger” is period between June and October (Fratkin 1991: 39). These local terms clearly evince the distinctive pattern of food

scarcity associated with the rainfall pattern.

Figure 2-1: Distribution Map of East African Pastoral Peoples



Map courtesy of Dr. Elliot Fratkin

Nomadic Ariaal and Rendille pastoralists' economic system conformed to seasonal patterns of rainfall and natural vegetation as well as to the biological cycles and needs of their animals, with its most difficult time coming at the end of the dry season

(Fratkin et al. 1999a: 729, 732; Smith 1997: 168). Rainfall is important to the Ariaal and Rendille pastoral economy mainly for two reasons: it governs vegetation growth and thus the pasture availability for the livestock, and it governs the availability of drinking water for both human and livestock populations (Fratkin 1991: 39). Securing pasture and water for the livestock is crucial for the human population because they affect the subsequent amount of milk which is the most important food available for human consumption (Fratkin 1991: 39).

2.1.2 Ethnic Identities of the Ariaal and Rendille

The Ariaal and Rendille are two related ethnic groups. The Rendille are Cushitic speakers distantly related to the Somali. They subsist by herding camels and small stock such as goats and sheep in the arid, low lying areas of Marsabit District (Fratkin et al. 1999a: 729). Rendille camel herders must stay in the lowlands to graze their camels and to avoid ticks and diseases harmful to camels which are prevalent in the more forested highlands (Smith 1997: 73-74). Rendille are dependent upon camels, as they can survive in extremely arid environments, and can tolerate almost two weeks without watering, converting poor quality arid range-land forage into milk and meat (Fratkin 1998: 42).

The inception of the Ariaal as a distinct ethnic group began during a time of disasters including disease epidemics, droughts, famine, and war in the late nineteenth century when immigrant families from four different ethnic groups – the Rendille, Samburu, Maasai, and Boran – united to recuperate from the hardship (Fratkin 1991: 125). Reflecting this origin, the Ariaal speak both Cushitic Rendille and Nilotic Maa language of Samburu (Fratkin 1998: 5). In addition to camel and small stock, Ariaals herd cattle.

Unlike camels, cattle require more frequent feeding and watering in the higher altitudes (Fratkin 1998: 4-6). Thus Ariaal have occupied the areas in between deserts and highlands, where herding both camel and cattle is manageable (Fratkin et al. 1999a: 729).

Despite this basic distinction between the groups, the Ariaal and Rendille share much in common in their economic, political, and social organization due to their shared history and nomadic pastoral adaptation to arid environments (Smith 1997: 76). They have a long history of intermarriage so that the issue of ethnic distinction (i.e., who belongs to which group) is not clear-cut and often flexibly manipulated depending upon the context. In an East African pastoral society where “periodic droughts, diseases, wars, movements of people, and innovations [have] constantly blurred ethnic boundaries” a tidy division of exclusive ethnicity hardly corresponds with the complex realities of life (Spear 1993: 1-2).

2.1.3 Labour Organization

Ariaal and Rendille pastoral economy is organized along age- and gender-based division of labour and behavioural norms. In a nomadic pastoral community, married men, or elders, are responsible for many aspects of animal husbandry as well as other economic, ritual and political activities for the community. Unmarried men or warriors and adolescent boys and girls spend most of their time away from their families in distant cattle herding camps (Fratkin 1998: 78, 83). However women’s roles are specialized in the domestic arena. For example, women are responsible for milking the domestic settlement’s cattle and small stock, for maintaining the household, and for providing child care and veterinary care to nursing stock (Fratkin 1998: 82).

According to a Rendille woman, “women milk the animals and they control the milk” (quoted in Smith 1997: 222). Mitchell (1997: 40) who studied the Ariaal and Rendille female milk marketing elaborates:

Regardless of which sex performs the milking ... it is the woman who has access to the milk and the right to distribute it. She decides how much milk to keep for household subsistence and for the production of dairy products ..., how much to donate to close kin and friends, and how much if any, to sell.

Nonetheless, their substantial labor contribution to livestock production rarely receives tangible rewards, neither in cash nor livestock, while their younger brothers’ or hired herders’ labor receive such payments (Fratkin 1998: 63). The strict gender-based ownership norm also prohibits women from owning livestock. They have a right to the animals’ milk, but animals always belong to males, either her father, husband, or son (Fratkin 1998: 62). Based upon the “lack of ownership rights in livestock; lack of decision-making ability in marriage, divorce, and decisions over children; and lack of political voice in village and extra-village affairs” women’s status is described to be low in Ariaal and Rendille nomadic pastoral societies (Fratkin 1998: 62).

2.1.4 Diet of Ariaal and Rendille Pastoral Nomads

Milk provides the majority of daily food for Ariaal and Rendille nomads, supplemented by meat and blood from their animals, as well as grains obtained by trade when milk is scarce (Fratkin et al. 1999a: 731). Milk, either fresh or curdled, is the food consumed most often by pastoral Ariaal and Rendille people (Fratkin 1991: 52). On average, a person in a typical Ariaal household may have access to 1.5 liters of milk daily

although actual intake varies significantly by “both seasonal supplies and by differential consumption patterns based upon age, gender, and wealth differences (Fratkin 1991: 52, 1998: 84). Aside from milk, which is consumed by all when available, dietary patterns are also defined by one’s age and gender, closely related to divisions of labour. While meat and blood provide meaningful supplements for the diet of adult males, women and children rarely consume these food items (Fratkin et al. 1999a: 731), except on special occasions. For example, a woman may be given these items immediately after giving birth (Fratkin 1998: 85).

The major dietary strains on nomadic Ariaal and Rendille pastoralists originate in the seasonal food and water scarcity during the dry season when the number of watering points diminishes and the remaining vegetation cover feeds fewer and fewer stock (Sobania 1988: 222). This is when the dietary contribution of milk diminishes, and is replaced by increasing amounts of grains, tea and sugar, obtained by selling livestock and their skins (Fratkin 1991: 51, 105). Nestel’s study (1986: 15) among the Maasai, another pastoralist group of Kenya and Tanzania, demonstrated that nutritional status was determined by milk availability, “which influenced the quantity and type of food purchased and the type of diet eaten.” This may also be true with the Ariaal and Rendille. “Both the Ariaal and Rendille sell considerably more animals during the dry season than the wet, and more stocks are sold during drought years than non-drought years when milk supplies are low and the need to purchase grains increases” (Fratkin 1991: 105). Grains, predominantly maize, are mainly obtained by selling small stock and male cattle (Fratkin et al. 1999a: 729). Toward the end of a dry season is the time of hunger when both protein and calorie intake decline dramatically (Fratkin 1998: 85-86).

Due to the scarce and unpredictable timing of rainfall, this “seasonal” hunger may be prolonged, at times extending for months or even years, in case of droughts. The strategies for survival which were (and still are to some extent) commonly used by the pastoral groups of northern Kenya included overstocking in good times so that at least some animals may survive droughts, from which whole herds can be re-built (Fratkin and Roth 1992; Roth 1996). This strategy requires long-distance moves in search of new pastures (Sobania 1988: 222). Ariaal and Rendille nomadic pastoralism featured high mobility within their herding territories, actively searching for regional patches of rain, grass, or water holes, in addition to sales of their livestock (Fratkin 1998: 69-70). While precarious existence at times, as long as they had sufficient livestock holdings and access to varied territories, nomadic pastoralism offered the Ariaal and Rendille a sustainable adaptation for a long time, dating back at least over 200 years (Fratkin 1998: 43). The specialized cattle-keeping pastoralism in East Africa itself dates further back to 4,000 years ago (Fratkin 1998: 42).

2.1.5 Community 1: Lewogoso

In order to give more concrete examples of an Ariaal and Rendille nomadic pastoral community, this section reviews previous studies of Lewogoso by Fratkin (1991, 1998). Lewogoso comprises the Lewogoso Lukumai sub-clan (Lewogoso), one of twenty-five Ariaal clan settlements, located at the base of the Ndoto Mountains, as shown in Figure 2-2. Lewogoso is a large pastoral settlement with a population of 250, composed of several lineages of patrilineally related families (Fratkin 1998: 51, 89). The actual size of the settlement ranges “from a single large circle of over fifty houses to

several circles spread apart from each other” depending mainly upon variations in vegetation and other environmental and political conditions (Fratkin 1998: 97).

Herders from Lewogoso move “their animals in independent herding groups orbiting around in semi-permanent locations ... claim[ing] the area along the Ndoto Mountains near Larapasie swamp and the Milgis River” (Fratkin 1998: 81). Men and boys herd camels close to the settlement so that they may return before nightfall each day. In contrast, cattle are herded by unmarried men, warriors, and adolescent boys and girls in the more distant areas in the highland valleys of Ndoto Mountains, who rarely return to the settlement. Small stock stay within the settlement, taken care of by women and girls unless it becomes too dry to keep them there, in which case they are grazed in camps (Fratkin 1998: 81-82).

Figure 2-2 : Map of Northern Kenya



Map courtesy of Dr. Elliot Fratkin

Women perform countless tasks in Lewogoso, but they appear to spend a good portion of their time in leisurely activities (Fratkin 1998: 82). A time allocation study by Fratkin in 1987 (Fratkin 1998) gives us a good idea about a typical day of an Ariaal mother. On average, 36.7% of a woman's day in Lewogoso was devoted to household activities, 13.9% to livestock related tasks, 13.9% to manufacturing tasks, and 35.4% to leisure activities (Fratkin 1998: 82; Smith 1999: 141-5). Household activities featured childcare, cooking, eating, cleaning, washing, making fire, shopping, and fetching firewood and water. Livestock tasks included grazing, watering, milking, inspecting animals, and giving veterinary care. Manufacturing tasks involved "the creation and maintenance of all the material goods of domestic life" including carving milk containers, weaving roof mats, making floor mats, sewing leather skirts, creating bead jewelry, as well as building houses (Fratkin 1998: 94-95). Leisure activities covered sleeping, sitting, visiting, chatting, and socializing (Smith 1999: 141-145).

Diet in Lewogoso is strongly affected by the seasonal fluctuation of rainfall and consequent milk availability. Residents obtain the majority of their diet from their livestock, primarily in the form of milk, complemented by meat and blood (Fratkin 1998: 72). In Lewogoso, camels supply the majority of milk "yielding an average of 3.5 liters of milk daily and reaching 10 liters daily in wet seasons, which humans share in roughly equal amounts with nursing calves and kids" (Fratkin 1998: 73). Although cattle also produce milk, their contribution to the female diet is much less significant because cattle are herded on the highlands, away from the lowland Ariaal settlements for most of the time. If cattle contribute to the female diet, it is likely in times of good rainfall in wet seasons when cattle are closer to the settlements. Grains, predominantly in the form of

maizemeal, are prepared as porridge, and “consumed with milk, sugar, and butter in good times” (Fratkin 1998: 85). In the wet season, milk provides more than sufficient amounts of protein, exceeding the WHO recommended protein allowance (Fratkin 1998: 84-85).

During the dry season when milk becomes increasingly scarce, blood from camels or meat from slaughtered small stock assume larger portions of the male diet, although these items generally do not contribute to the women’s diet (Fratkin 1998: 85). As the dietary contribution of milk diminishes during the dry season, people, especially women, consume increasing amounts of maizemeal, tea and sugar, obtained by selling livestock, mostly cattle, and their skins (Fratkin 1991: 51, 105, 1998: 76). Maizemeal is prepared just plain without milk or butter unlike in good times (Fratkin 1998: 85).

2.2 Toward Sedentism

Today, many Ariaal and Rendille people are settling down in agricultural settlements, mission centres, or urban communities largely in response to drought-related livestock loss (Fratkin 1991, 1998; Fratkin and Roth 1990; Fratkin et al. 1999a, 1999b; Smith 1997). Behind this immediate factor, however, there have been, more long-term political and ecological pressures that progressively restricted their herding territories. In the precolonial period, Rendille moved regularly from the Turkana lakeshore to east of Marsabit Mountain, practicing a transhumant lifestyle covering very wide areas (Waller and Sobania 1994: 50). Ethnic divisions among pastoral people in northern Kenya had been more fluid then. The effects of unknowns, such as poor renewal of vegetation and water, as well as threats from raiders and diseases, were dealt with through the manipulation of social relationships forged by the web of agnatic marriage ties, as well as

that of gifts and loans of both human labour and animals across ethnic divisions (Sobania 1988: 219, 1991: 122-136). The system of gift giving and loan granting cultivated social relationships, in which reciprocal obligations in effect provided the ultimate insurance for the unknowns (Sobania 1991: 130-131). The notion of “gift” discussed by Mauss (1967) was at work among numerous groups of pastoralists who occupied the region of Lake Turkana beyond societal boundaries. When difficulties arose, those pastoralists who invested in relationships beyond the bounds of their own society managed to have more options of assistance open to them (Sobania 1991: 136).

This flexible reciprocal strategy became particularly visible during the disasters of the 1880s and 1890s. These disasters were the livestock epidemics of bovine pleuro-pneumonia and rinderpest, as well as the human epidemic of smallpox, all of which swept through northern Kenya one after another for a relatively short duration. Bovine pleuro-pneumonia and rinderpest, for example, severely affected the cattle-keeping Samburu. They were devastated by both epidemics and resulting famine, leading to starvation and death for many, and massive dislocations for the survivors (Sobania 1991: 137). For some pastoralists, such as certain groups of the Maasai, raiding neighbouring tribes’ herds was a desperate solution to these disasters, temporarily increasing the inter-tribal conflicts over livestock (Waller 1988: 75-80).

The Rendille were much better off during these epidemics since neither of them affected the camel herds. However, when the smallpox epidemic of the 1890s came, the Rendille were among the most severely hit. They lost much of their labour force consequently threatening the very existence of their production system (Sobania 1991: 136). This dearth of human labour provided the Samburu and Ariaal who lost their

livestock to the preceding bovine epidemics the opportunity to offer their labour. The Samburu and Rendille who specialized respectively in cattle and camel herding were thus “unable to exist wholly within the framework of their economics and often had no recourse but [to] migrate” and yet their flexibility enabled both groups to survive the disasters together (Fratkin 1998: 46; Sobania 1991: 137).

The early decades of the twentieth century saw the demise of the flexible strategies which facilitated the pastoralists’ survival in their changing environment (Sobania 1988: 230, 1991: 137-140). This was largely due to the expanding colonial authority whose policies focused on establishing solid ethnic divisions for the ease of their administration and taxation (Sobania 1991: 139-140). Such government policies had irreversible consequences not only on their geographic mobility but also on social dynamics among the pastoralists. The artificial boundaries imposed by the government brought an end to the peaceful means of contact and exchange which had previously ensured the societies’ survival of localized crises (Sobania 1991: 139-140):

By limiting societies to bounded regions, and thereby creating in each increased need for greater self-reliance, the colonial authorities heightened the ethnic consciousness of each society. In response, cultural identity distinct from that of geographic and cultural neighbors [emerged], further driving in the wedge that split long-standing relations of reciprocity between the peoples....

After the disasters in the late nineteenth century, the Rendille’s herding range became increasingly restricted by the intrusion of other neighbouring ethnic groups such as the Turkana, Boran, and Gabra. This was followed by the British issuance of the Tribal Grazing Areas Act in 1919 which resulted in the formal confinement of the Rendille to certain fixed water holes in the southern region of the district (Fratkin 1991: 121; Sobania

1988: 226-234). As a result, Rendille annual migrations were dramatically diminished from 131-294 km in 1923 to 13-73 km in 1978 (Fratkin 1991: 122). During the 1960s, Boran/Somali and Ariaal warriors fought a major battle in the *Shifita* war. Hostilities from this time persisted in the form of the Boran's (and Turkana's) sporadic livestock raids and ambushes against the Ariaal and Rendille (and vice versa). This lasted well into the late 1990s (Fratkin 1998: 48) when a peace accord was agreed upon among them (Roth personal communication). Ariaal, Rendille, and Samburu managed to maintain friendly relationships through active economic and social exchanges and reciprocity, including intermarriage (Fratkin 1998: 40-48).

The imposed limitations on herding mobility and resulting overgrazing on confined areas had a detrimental effect on both the Rendille's well-being and their environment (Sobania 1988: 230-231). To counter this, major water development projects were introduced in 1949 bringing pans, enlarged catchments, new boreholes, and tapped springs to the more marginal lands, use of which was previously limited to wet seasons (Sobania 1988: 232). The increasing restrictions on their grazing resources provided many Rendille and Ariaal pastoralists with incentives to settle around permanent water holes. This resulted in the further concentrations of livestock in those newly available, better-watered areas. The benefits from such projects were often short-lived; concentrations of livestock ultimately lead to greater degradation of the environment through localized over-grazing (Sobania 1988: 232-233).

Government officials mistakenly reasoned that the environmental degradation as well as livestock epidemics were due to the Rendille's over-stocking of the camel, and so justified halting all inoculations of the camel in the area. It was in this context that the

Rendille were hit by the livestock loss associated with the 1949 epidemic of anthrax, another livestock disease (Sobania 1988: 234). Once decimated, the camel herds were difficult to re-stock. This was due to the constraints on the fertility of camels, such as their longer gestation periods, low birth rates, and rain-induced ovulation cycles (Sobania 1991: 122). This special difficulty associated with camel herding perhaps propelled Rendille camel herders rapidly toward sedentarization.

After 1963, Western missionaries, especially those from the Catholic Church, provided additional incentives for sedentism (Sobania 1988: 233-235). When the drought of 1968-1971 devastated Marsabit District, many settlements were equipped with enough infrastructure to effectively distribute famine relief to the Rendille. When another drought came in 1973 relief-distribution facilities were established by the Marsabit Diocese, which evolved into permanent mission stations (Fratkin 1991: 122). The Rendille now mostly concentrate in areas surrounding missions and famine relief areas, and are in transition from subsistence pastoralists to town dwellers and agropastoralists (Fratkin 1991: 123). Today, over 50% of the 25,000 Rendille people have settled permanently in or near towns (Fratkin et al. 1999a: 729). Ariaal have been, relatively speaking, able to circumvent the restriction with their more flexible and opportunistic adaptation of mixed-species herding although their future as nomadic pastoralists is “far from certain” (Fratkin 1998: 1, 37).

2.2.1 Community 2: Songa

Songa, an irrigation agricultural settlement of former Rendille pastoralists with a population of 2,750 (Smith 1997, 1998, 1999), provides an example of the cultural and

socioeconomic changes associated with the agricultural sedentarization of pastoralists. Located on the highland of Mt. Marsabit (see Figure 2-2), Songa was originally established by the African Inland Church in 1973 to provide an alternative means of subsistence for those who lost their livestock in the prolonged series of droughts in the late 1960s and 1970s (Fratkin 1991: 123; Fratkin et al. 1999a, 1999b: 730; Smith 1997: 1).

2.2.2 *Agricultural Economy of Songa*

After struggling for several years, Songa developed into a productive agricultural community on the location where permanent human settlement was once considered improbable. The drip irrigation system of Songa uses gravity fed pipes, enabling the population to raise a variety of agricultural crops without relying on high maintenance ditches (Smith 1997: 33). This reliable water source coupled with its rich volcanic soil (Fratkin 1991: 123; Smith 1997: 104), as well as a stable market demand for agricultural produce from the district capital town of Marsabit that is geographically accessible on foot (Smith 1997: 94, 1998: 462), all contribute to Songa's successful agricultural economy.

The main crops grown in Songa are *sukuma wiki* (collard greens), maize, and beans (Smith 1997: 95-6). In theory, men are in charge of a larger quantity of cash crops such as maize, while women sell small quantities of subsistence garden surplus (Smith 1997: 52). In practice, however, men rarely harvest a large enough surplus of maize to sell in the market (Smith 1997: 52). Surplus produce from the women's subsistence gardens may be small in quantity at any one time but available all year around, in effect greatly

contributing to the household's daily cash income (Smith 1997: 12). Everyday, local sellers in the town of Marsabit purchase most local crops from Songa including *sukuma wiki*, tomatoes, oranges, papayas, mangos, and bananas (Smith 1997: 95).

Songa is a doubly successful community because in addition to agriculture, it has "successfully" affected residents' ideology (Smith 1997). While many pastoralists who adopt agriculture eventually choose to return to pastoralism (Campbell et al. 1999: 335; Smith 1997: 33), residents of Songa seem to stay and continue agriculture, maintaining a strong connection to the market economy (Smith 1997: 104, 257). One of the reasons for pastoralists to "re-adopt" nomadism may be their traditional ideology in which a high value is placed upon animals and nomadism (Campbell et al. 1999: 352). While the Ariaal and Rendille in Songa also value their animals highly for their ritualistic and social importance, they consider their farms as a more valuable economic resource than their animals because the former provide them with a more stable life-style (Smith 1997: 33).

Families in Songa appear to maintain some connections to the pastoral economy although the strength of such connections may vary vastly by wealth status of the family from holding only a few animals grazed nearby, to holding many more animals in distant camps. Many Songans keep only a small number of domestic animals in the settlement for their milk for domestic consumption. They can keep only a small number of animals mainly because of the lack of available space for animals and the potential damage to the garden crops their animals may inflict (Smith 1997: 89-90). When a herd owner is wealthy enough to have more animals than he can keep in Songa, animals are herded in distant locations, either by warriors from Songa in the reserve or by their pastoral

relatives. In either case, they maintain strong connections to the pastoral sector of the area (Fratkin 1991: 123; Fratkin et al. 1999: 730; Smith 1997: 89-90). Such households supplement their income by the cash generated through the sales of these cattle or small stock (Fratkin 1991: 123).

Women in Songa appear to have more work to do than nomadic women (Smith 1997, 1998, 1999). For example, Songa women's workload has increased relative to that of their nomadic pastoral counterparts, mainly due to the new responsibility for the tending and marketing of garden produce (Fratkin: personal communication; Smith 1997: 248, 1999: 149). Time allocation study found that a typical Songa woman spent 43.2% of her day for household activities, 26.7% for farming and marketing tasks, 3.3% for manufacturing tasks, and 25.5% for leisure activities (Smith 1999: 141-145). Compared to the previously mentioned time allocation study on Lewosogo women, Songa women spent substantially more hours for household activities and farming and marketing tasks. Meanwhile the hours they spent in manufacturing tasks were reduced. But this reduction did not compensate for the increased workload for other tasks. As a result, their leisure time became shorter than the Lewogoso women's by 10% (Smith 1999: 141-145).

In Songa, the gendered power arrangement has shifted positively for women (Smith 1997, 1998). As the importance of the herd has diminished, women and unmarried males have become less dependent on elders (Smith 1997: 6-7, 10). In contrast to nomadic pastoral women who rarely have access to cash, women in Songa now provide most of the daily cash and subsistence for households through their produce sales of local crops such as *sukuma wiki* (Smith 1997: 10, 13, 95; 1998: 464). A Songa woman claims, "[our life is good] because we are planting *sukuma wiki*. You are selling and getting

money” (quoted in Smith 1997: 136). Produce sales, particularly that from *sukuma wiki* is very lucrative, and Songa women grow it in a large quantity and sell it at the market (Smith 1997: 95-96). There is agreement in Songa that women control *sukuma wiki* in the same way they control milk in the pastoral economy. For example, a woman from Songa said that in a pastoral society, “women milk the animals and they control the milk. Here women plant *sukuma wiki* and sell it, so they are the ones who control it” (quoted in Smith 1997: 222). In pastoral communities, even though women have control over the allocation of milk, due to the prohibitive distance from a town, it rarely translates into cash income (Smith 1997: 13). Although women in Songa still do not own the land, they can claim control over the produce they harvest in the same way they have rights to the milk they have obtained from the family’s herd” (Smith 1997: 13).

Adding another dimension to the women’s new situation, the degree of integration to town markets depends upon women’s household economic status. Those who own sufficiently productive resources can sell surplus vegetables to regular customers in town whereas the poor without such resources cannot (Fratkin and Smith 1995: 450) Currently, there is still limited information available to reveal how the new role and responsibility, as well as the varying degree of market involvement of women may be affecting their nutrition and health. Among few such studies, a cross-sectional study of Rendille women in 1995-6 by Shell-Duncan has reported the signs of increased disparity in economic status as well as differentiated access to milk, in which women from poorer households were relatively disadvantaged (2001: 30).

The effect of seasonality on the diet of Songa residents is yet to be explored, but some pieces of information imply that seasonal dietary stress may have been also reduced

relative to their pastoral counterparts. For example, Smith (1997: 103) reports that during his study Songa families received less famine relief compared to the Ariaal and Rendille households in other places. During the dry season when pastoralists may face severe water and food scarcity, Songa families can consume stored food from their previous harvest (Smith 1997: 97). Income generated from the year-round sales of garden surpluses may be used to purchase other food items such as tea or sugar, or maize flour when family stores of maize have run out (Smith 1997: 88, 105).

2.2.3 The Rendille Sedentarization Project

Fratkin, Nathan and Roth have investigated the consequences of sedentarization in five Ariaal and Rendille communities, one nomadic control and four now sedentary communities, each with distinct ecological setting and economic specialization. These communities include Lewogoso, Karare, Korr, Ngurunit, and Songa (Fratkin and Roth 1990; Fratkin et al. 1999a, 1999b; Nathan et al. 1996). Lewogoso and Songa have already been described in the preceding sections. Brief descriptions of the three other communities are as follows:

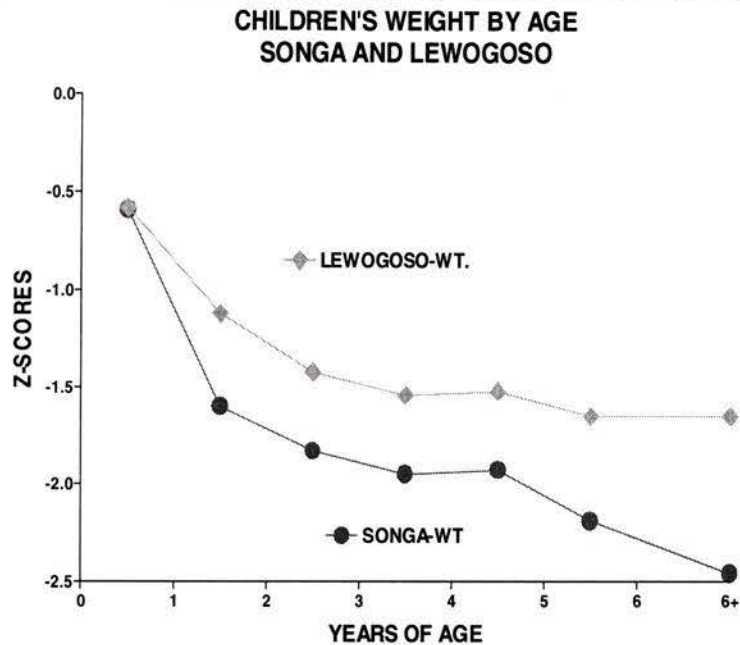
- 1) Karare is a highland community of 2,000 people, located on Mt. Marsabit, where residents herd cattle and raise dryland maize. Karare women earn cash from milk marketing (Fratkin et al. 1999a).
- 2) Korr is a lowland town with a population of 6,000 located in the Kaisut Desert where scarce vegetation prohibits herding of livestock (Fratkin et al. 1999a). Consequently many Korr residents depend upon famine relief supplies, while those more fortunate earn livings from running shops or trading livestock (Fratkin et al. 1999b).

- 3) Ngurunit is an agro-pastoral community with a population of 1,200 located in a valley in Ndoto Mountains (Fratkin et al. 1999a), where many residents keep some livestock in their compounds while those without livestock make living as wage workers (Fratkin et al. 1999b).

Fratkin et al. (1999a, 1999b; Nathan et al. 1996; Roth et al. n.d.) have consistently documented adverse growth-patterns of children in all of the above four sedentarized communities. In terms of the age-independent measurement of weight-for-height, for example, all four sedentarized communities had much elevated rates of child malnutrition relative to the nomadic community of Lewogoso (Fratkin et al. 1999a). Also, when Lewogoso and Songa were compared to each other in terms of weight-for age values, children from Lewogoso were much better-off than those from Songa, as depicted in Figure 2-3. For all ages between one and six, children in Lewogoso scored statistically significantly higher values. This change confirms a decrease in dietary protein, associated with their decreased access to pastoral foods such as milk (Fratkin et al. 1999a). This negative nutritional change in children is also consistent with an economic transition from a subsistence-oriented economy, where people have more control over food production and consumption, to a market-oriented economy, where market-obtained or store-bought foods govern the majority of diet and thus control is taken away from the people and given to the market.

Since the new diet had a negative impact on sedentarized children's nutritional health, a similarly negative impact might be seen among other members of their community, particularly the mothers of these children.

Figure 2-3: Growth Pattern (Weight by Age) of Children by Community



Adverse growth patterns of children in Songa, a sedentarized agricultural community, are clearly visible in their increasingly lower weight-by-age values relative to those for children in Lewogoso, a nomadic pastoral community. (Graph courtesy of Dr. Eric Roth)

Summary

This chapter delineated the ethnographic and historical contexts of this study, in which both political and ecological factors simultaneously affected the Ariaal and Rendille toward their sedentism. The two contrasting study communities – nomadic pastoral Lewogoso and sedentary agricultural Songa – illuminated a host of social, cultural, and behavioural changes associated with agricultural sedentism, all of which potentially affect the dietary practices and nutritional requirements of the peoples. The review of the previous studies on children's nutrition and health pointed to the negative growth patterns associated with their sedentism. The reduced intake of dietary protein was suspected to be the key reason for this negative consequence.

Chapter 3 considers the significance of dietary protein in order to understand how this nutrient may affect human nutrition and health.

Chapter 3

Sedentarization and Dietary Protein

This chapter is a review of literature on dietary protein not only as a crucial nutrient for human health but also as the scarce commodity whose accessibility is influenced by subsistence modes, as well as socioeconomic and cultural factors, all of which are relevant to agricultural sedentarization of pastoralists.

3.1 Dietary Protein and Human Health

We know much about protein as a nutrient, and how it generally contributes to the maintenance of human life. Humans consume proteins and break them down into amino acids, and then recombine them into different proteins in our body (Foster 1992: 61; Whitney et al. 1990: 140-143). There are about twenty amino acids required of the body to make different proteins that are indispensable for its survival. To survive humans must consume sufficient quantities of these essential amino acids since we are not capable of synthesizing amino acids in our body, unlike some other organisms such as yeast or algae (Foster 1992: 61).

There has long been a controversy over the relative importance of calories versus proteins (Foster 1992: 61). Calories are crucial for physical activities as well as a variety of activities within the body, including maintenance of body heat. Proteins are essential not only for building and repairing the body but also for a host of other essential functions such as carrying oxygen throughout the body, producing disease resistance, carrying nutrients into and out of cells, and acting as enzymes, to name a few (Foster 1992: 61). Protein nutrition is also an important determinant of bone length during childhood;

“During prolonged illness or undernutrition, bone lengthening may be retarded or stopped altogether” (Foster 1992: 52).

Back in the 1960s, the importance of protein used to be strongly emphasized, and the Third World nutritional problem was considered to be due to the deprivation of “proper” protein that originated from animal sources. By the 1970s, the importance placed upon protein, especially animal protein, began to diminish, as studies showed that the problem was better attributed to calorie deficiency. For example Gophalan’s 1970 paper (quoted in Foster 1992: 74) suggested that the protein shortage “would disappear as the caloric shortage disappeared.” Further, Francis Moore Lappe (1970 quoted in Foster 1992: 74) popularized what is known as protein complementarity, the idea that by appropriately mixing pulses (beans) and cereals, one could obtain well-balanced amino acids, comparable to that of high quality animal protein. Animal products like meat, milk, cheese, and eggs are ready sources of balanced proteins, but a mix of pulses and cereals is the cheapest source of balanced protein (Foster 92: 76). This meant that by mixing maize and beans in one’s diet, for example, one could obtain the balanced amino acids roughly equivalent to animal protein. (Foster 1992: 75)

In the 1980s, the biological mechanisms whereby the body accommodates to changes in protein intake were the subject of extensive study (Jackson 1990: 90). Further, the importance of protein gained renewed attention as researchers managed to establish the recommended intake-levels by body weight (Foster: 1992: 74). Irrespective of the relative importance of protein over carbohydrate or vice versa, there is a crucial difference between carbohydrates and protein. Excessive protein intake by humans seems to be fine, but the reverse is not true. According to Foster (1992):

If a human overconsumes protein but is short on carbohydrates and fats, the body can burn the surplus protein as energy.... But it does not work so well the other way around. If the body is short of protein and long on carbohydrates and fats, it can make limited quantities of some of the essential amino acids, but cannot do the whole job. So we end up short on enough protein for an active, healthy life (62).

The body can survive long-term on a diet with insufficient caloric values. But three groups of people require special attention to their protein needs: lactating mothers, pregnant women, and infants. "Lactating mothers need about 40 percent more protein in their diet than do nonpregnant/nonlactating women. Pregnant women need some 65 percent more than nonpregnant/nonlactating women. But infants, especially at weaning time, need the most protein dense diet of anyone" (Foster 1992: 83), since they suddenly lose adequate protein that they used to consume from breast-milk. Because of these reasons, pregnant women, lactating mothers, and infants "need more protein than they can get from consumption of cereals alone. They benefit substantially from a pulse component in their diet" (Foster 1992: 83). Also if possible, milk and other animal-products will substantially contribute. These considerations are crucial for the nutritional health of these three groups to attain adequate protein as well as calories.

When an individual does not get the calories or protein necessary for normal growth, development, body maintenance, and the energy required for ordinary human activities (Foster 1992: 16), we use the term undernutrition, or more technically protein-calorie malnutrition (PCM), to describe the state. In extreme forms, PCM may lead to potentially fatal nutritional disorders such as marasmus, kwashiorkor, and pellagra.

3.1.1 Protein and Wealth

Risk populations for protein deficiency can be defined by socioeconomic terms. Protein is a scarce commodity. In general, protein in foods is less abundant than carbohydrates or fat. This relative scarcity of protein makes protein-rich foods more costly than those foods which mainly contain carbohydrates or fat (Foster 1992: 64-70). For example, in West Pokot District, north-west Kenya in 1995, goats were twelve times more, and cattle were sixteen times more costly than maize grains in caloric terms of trade (Zaal and Dietz 1999: 180) In caloric terms, a steer is equivalent to 65 kilograms of maize. In 1995, 65 kilograms of maize cost between Ksh. 280 and 325 (calculated from Ksh. 8-10 / 2-Kg tin). In comparison, cattle prices were above Ksh. 4,000 (Zaal and Dietz 1999: 197). The high cost of protein is also evident at the retail level. This is the reason why poor people tend to substitute carbohydrates and fats for protein in their diet, resulting in protein underconsumption (Foster 1992: 62). Adult protein requirements “are met by most traditional developing country’s diets ... only when populations can afford these diets” (Foster 1992: 83). Differential access to protein by economic status is also evident at a macro level. Countries with low incomes tend to obtain a greater proportion of their calories as cereals, the cheapest sources of proteins and calories, while high-income countries consume greater proportions of the calories in the diet from animal products (Foster 1992: 70-73; FAO 1996 cited in Kagawa 2000: 445-447).

3.1.2 Protein and Pastoralists

Galvin and Little (1999) associate physical and biological characteristics of East African pastoralists with their high-protein and low-calorie diet. They succinctly discuss the potential ramifications of a high protein/low calorie intake in nutritional status of

Turkana pastoralists:

Among human populations, this is an unusual dietary pattern. When combined with low seasonal energy intakes and weight loss, high protein intakes may be necessary to replenish muscle mass lost during hungry periods. High protein intake is likely also to 'drive' growth in height and contribute to the tall stature of the Turkana. How does this dietary pattern influence reproduction and the growth of children? Despite the low energy intakes of women, fertility is relatively high..., but women show small gains in weight during pregnancy and sustain losses in body fat throughout their reproductive years. The risks to late parity infants may be increased because of these losses. Morbidity of children is relatively high, which when combined with limited energy intake, appears to contribute to slow growth, yet tall stature at maturation. (Galvin and Little 1999: 144-145)

The high protein diet of Ariaal and Rendille pastoral people may also have similar ramifications to their physical and health characteristics. At minimum, the Ariaal and Rendille share a thin and linear physique with the Turkana. Dietary practice plays an important role in this, together with their inherited genetic potentials.

3.1.3 Protein and Sedentarization

Prohibited by the relatively high cost of dietary protein, a protein-rich diet rarely occurs among human groups (Galvin and Little 1999: 144). Nomadic pastoral diets are one of the rare exceptions among humanity for its tremendously high protein content. The previously mentioned three risk groups – infants, pregnant women, and lactating mothers – may be less vulnerable to protein deficiencies in nomadic pastoral society since these three risk groups are generally protected by their adequate access to milk protein. As well, a nomadic pastoral society may also be an exception to the general trend of differential access to protein by economic status. However, with sedentarization and economic transition from subsistence oriented pastoralism to market-oriented alternative economy,

such as agriculture, these exceptional qualities forged by the abundance of pastoral foods may disappear. Differential access to dietary protein may emerge based upon one's wealth, age, or gender statuses. Infants, pregnant women, and lactating mothers of the poor stratum of a community may be at the highest risk for protein malnutrition.

3.2 The Problem of Maize Protein

This chapter so far discussed a possible connection between sedentarization, economic status and dietary protein in general. But it has implied that a cereal-based agricultural diet is necessarily low in protein, ignoring the contribution of protein from plant sources. Particularly important for East African diets is maize. The dried maize kernel actually contains roughly 8.6 percent protein by weight (Kagawa 2000: 60-61). However, where maize is consumed in large quantity, pellagra, a protein (more specifically, niacin) deficiency disease, is high (Leonard 2000: 320). Why is not maize protein sufficient as a main source for human nourishment? It is because maize protein's nutritional contribution to humans vary depending upon the way maize is processed or prepared. In order to understand this, we need to examine the intersection of maize protein and the cultural behaviour of the people. This section will briefly explain the problem of maize protein, and consider the ramification to agricultural Ariaal and Rendille people in Songa who grow maize as a primary crop.

While maize contains protein, the maize protein is not readily available for humans since it is "deficient in its essential amino acids lysine and tryptophan, and niacin, a member of the vitamin B complex" (Katz et al. 2000: 173) which are essential for protein digestion. However, this problem is overcome in societies that have a long-established cultural response. For example, the use of alkali products such as ash,

lime and lye in cooking maize, as seen widely among Amerind populations, dramatically increases the concentrations of niacin, and thus improves its nutritional quality (Katz et al. 2000: 173; Leonard 2000: 319). This process is best represented by the alkali and heat techniques involved in tortilla making. These techniques enhance the balance of essential amino acids and free niacin available for human absorption (Katz et al. 2000).

However, there was no evidence of maize being prepared with alkali by the Ariaal and Rendille people in the ethnographic literature (Fratkin 1991, 1998; Mitchell 1997; Smith 1998, 1999; Spencer 1973). In places such as Africa, maize is a relatively recently introduced food. This high-yielding crop was perhaps transported “readily” while food *knowledge* might not have been transmitted. Katz (quoted in Leonard 2000: 320) proposed a lock-and-key model for understanding how cultural knowledge about food processing can enhance the quality of particular food resources. He argues that processing techniques likely develop first in areas where a particular crop is initially domesticated. Because the information about processing is distinct to the particular culture, it is less likely to spread than the crop itself. Consequently, this model predicts that utilization of the crop will be less effective outside of the “core” area until the appropriate cultural knowledge has been transmitted (Leonard 2000: 319). It is “lock-and-key” because domesticated, high-yield crops “often could not be used for widespread human consumption until processing techniques necessary for unlocking the full nutritional benefits were developed” (Leonard 2000: 320). This lag between food and food knowledge is potentially problematic.

There is a serious potential health ramification such as pellagra if the population’s diet depends primarily upon maize and does not include other food items on a seasonal basis to supplement the lack of tryptophan or niacin, or both (Katz et al. 2000:

174). Pellagra is a niacin deficiency disease, with the symptoms of dermatitis, diarrhea, and dementia. This problem has not been a concern for nomadic Ariaal and Rendille because they have been consuming maize only as a supplement or substitute for milk, and unless milk is scarce, consumed with milk to balance the nutrition (Fratkin 1998: 85). With agricultural sedentarization, however, Ariaal and Rendille may now consume maize in a much larger quantity but with a much reduced quantity of milk, subjecting them to the problem of insufficient maize protein, and increasing the potential for a protein deficiency disease. For example, pellagra became widespread in the U.S. South in the early twentieth century among people who subsisted on a maize-based, low-protein diet, which “supplied neither enough niacin nor enough of its amino acid precursor tryptophan to make up the deficiency” (Whitney et al. 1990: 204).

Summary

This chapter presented the significance of dietary protein, and demonstrated its relevance to the health of the peoples in sedentarization. The changing economy from pastoralism to agriculture, changing degree of dependence on market economy, changing socioeconomic dynamics, and changing values and behavioural norms, all affect protein content in the diet, which in turn affect the Ariaal and Rendille’s nutritional status and health.

Based upon the above considerations, the next chapter will generate a series of hypotheses, and describes the materials and methods used for testing them.

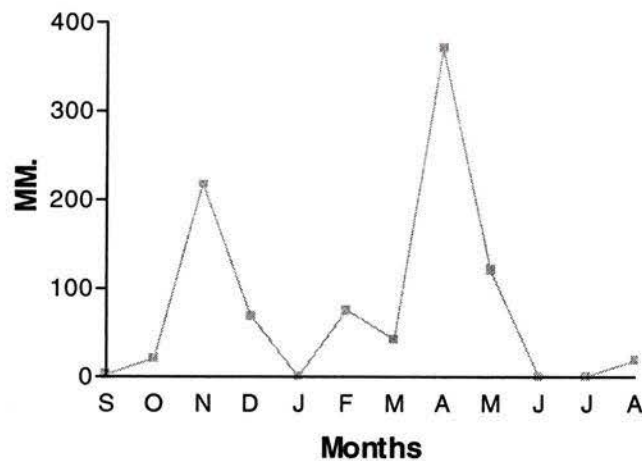
Chapter 4

Materials and Methods

4.1 Materials

The study period covers a one-year period from September 1994 to August 1995. This year was selected because of its bimodal rainfall pattern, characteristic of East Africa. Figure 4-1 clearly depicts this bimodal rainfall pattern, with peaks in November 1994 and April 1995.

Figure 4-1
Rainfall
September 1994 - August 1995



The number of mothers sampled in each community was 40 in Lewogoso and 38 in Songa. Table 4-1 summarizes the samples. The same mothers were sampled repeatedly six times, at intervals of two months. Originally 46 mothers in Lewogoso and 43 mothers in Songa participated in the project.

The samples from both communities are best described as availability samples. The common thread among mothers in both communities was that they all had children under the age of six at the time of data collection. According to Smith, who managed the

project in Songa, sampling of Songa mothers was structured so that the sample would reflect all four ridges or sections of Songa that were settled at different times (Smith: personal communication). The sample mothers from Lewogoso constitute a control group, representing nomadic Ariaal and Rendille pastoralists. The sample mothers from Songa constitute a treatment group, representing former pastoralists of Ariaal and Rendille in an agricultural settlement.

Table 4-1: Number of Sample Mothers

Communities	Lewogoso (Control Group – Nomadic Pastoral Community)	Songa (Treatment Group – Sedentary Agricultural Community)
Number of Mothers	40	38

Ages of five mothers from Lewogoso and seven mothers from Songa were unavailable. For the rest of sample mothers, the age distributions of the two communities were fairly similar to each other. The mean age of sample mothers from Lewogoso was 30.1 ranging between 20 and 48. The mean age of Songa sample was 30.8, ranging between 19 and 49. Figures 4-2 and 4-3 summarize the age distributions.

Reproductive status – pregnancy and lactation – of the mothers was recorded bimonthly as dichotomous variables. The number of women who were pregnant and who were lactating changed over the course of the year. Table 4-2 summarizes this. When lactation statuses were matched, that is, when lactating (or non-lactating) nomadic mothers and lactating (or non-lactating) sedentarized mothers were compared to each other, there were no significant age differences. Within the respective community, however, non-lactating mothers were slightly older than lactating mothers. Table 4-3

summarizes the age of sample mothers by lactation status.

Figure 4-2: Distribution of Mothers' Age in Lewogoso

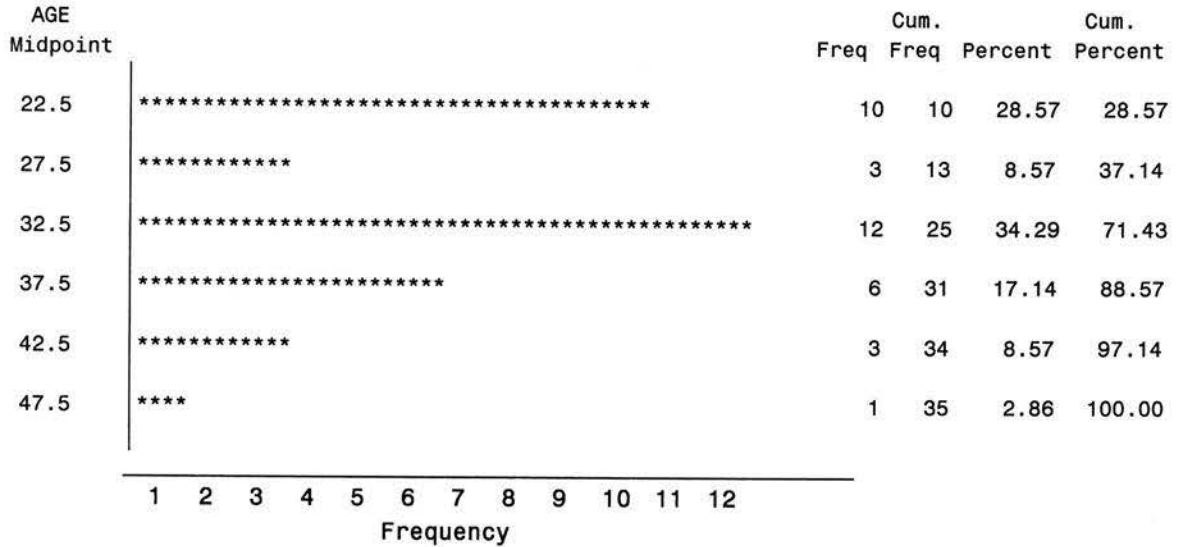


Figure 4-3: Distribution of Mothers' Age in Songa

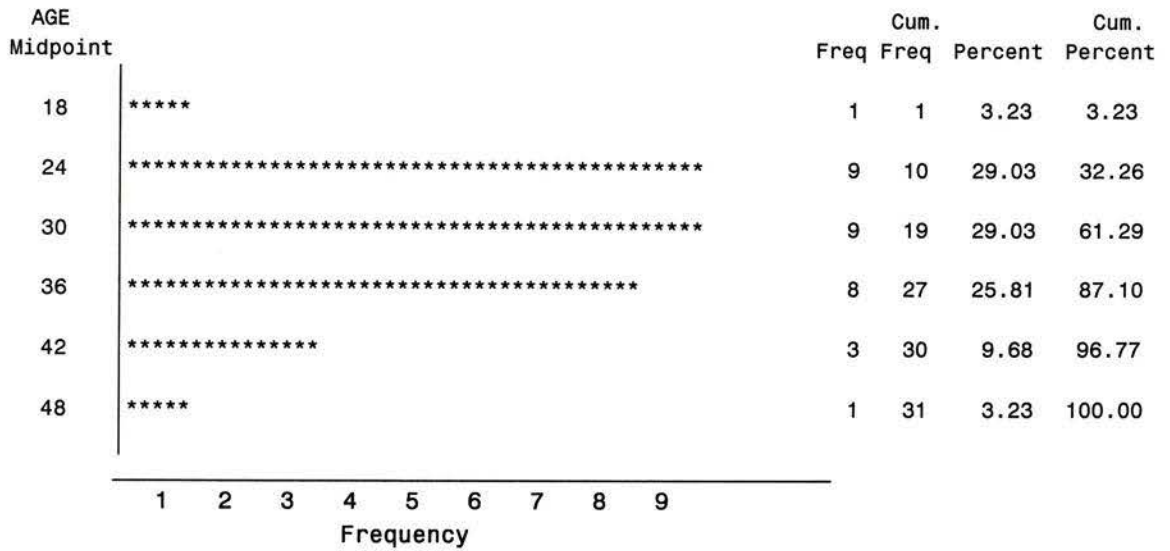


Table 4-2: Number of Mothers by Reproductive Status

Communities	Lewogoso		Songa	
	<i>Not Lactating</i>	<i>Lactating</i>	<i>Not Lactating</i>	<i>Lactating</i>
September	17	23	16	22
November	18	22	17	21
February	15	25	21	17
April	18	22	17	21
June	19	21	19	19
August	18	22	21	17
<i>Status</i>	<i>Not Pregnant</i>	<i>Pregnant</i>	<i>Not Pregnant</i>	<i>Pregnant</i>
September	34	6	31	7
November	35	5	33	5
February	35	5	32	6
April	34	6	35	3
June	31	9	34	4
August	30	10	31	7

Table 4-3: Mean Age of Mothers by Lactating Status

Communities	Lewogoso		Songa	
	<i>Not Lactating</i>	<i>Lactating</i>	<i>Not Lactating</i>	<i>Lactating</i>
September	34.20	28.25	32.15	29.83
November	32.75	29.16	32.71	29.24
February	32.92	29.55	32.47	28.79
April	32.36	29.33	33.77	28.67
June	31.89	29.65	33.14	28.88
August	31.71	29.94	32.87	28.88

A variable describing household economic statuses, divided into poor, middle, and rich was also available. Classificatory criteria were based upon the mixture of subjective and objective scales used by Fratkin and Smith (1995), including local field assistants' assessment of household wealth, along with calculation of livestock, wages, remittances and household expenditures.

There were large rates of absentees, especially among Lewogoso mothers. Nineteen out of 46 Lewogoso mothers missed at least one session out of six. Due to the

high mobility of households among the pastoral nomads, this was considered inevitable. Excluding all these individuals from the sample would result in not only making the Lewogoso sample size substantially smaller than that of Songa, but also would eliminate a large segment of valid data which offer a wealth of information. Thus mothers who attended at least four out of six sessions were included in the sample for both communities, resulting in the respective final sample size.

Survey data were collected repeatedly every two months. Surveys featured 24-hour dietary recalls, 30-day morbidity recalls, and anthropometric measurements. Table 4-4 summarizes these data.

Table 4-4: Repeated Measures Data

Dietary Intake	Morbidity Episodes	Anthropometric Statuses
24-hr Dietary Recall: <ul style="list-style-type: none"> ➤ Cups of Milk ➤ Servings of Starch, Sugar, Fat, Beans and Greens 	30-day Morbidity Recall: <ul style="list-style-type: none"> ➤ Colds ➤ Fever ➤ Diarrhea 	Anthropometric Measurements: <ul style="list-style-type: none"> ➤ Triceps-skinfold Thickness ➤ Mid-upper Arm Circumference ➤ Body Weight

The 24-hour dietary recall data covered the quantity of milk, as well as servings of starch, sugar, fat, beans and greens. Starch includes grains, mainly maize. Sugar is the refined sugar available in stores. Fat includes two sources of dietary fat: “e-ilata” or rendered fat from livestock parts such as sheep’s tail, and “kimbo” or store-bought vegetable fat that is now commonly used by the Ariaal and Rendille (Fratkin: personal communication).

The units of food servings, however, should not be taken to be “quantities” in the strict sense. The units of servings were somewhat loosely defined at the dietary recall

interviews, with the exception of milk, which was quantified in terms of the “measuring” cup commonly used in the district (Fratkin et al. 1999b; Fratkin: personal communication). Thus the recall data allowed rough estimates of typical day’s dietary intake and how it might have changed seasonally.

Anthropometric measurements included body weight, mid upper arm circumference (MAC) and triceps skinfold thickness (TSF). In general, MAC is considered to reflect muscle mass, skeletal size, and fat mass of the arm (Heyward and Stolarczyk 1996: 67). TSF is highly correlated with body fat (Roche et al. 1996: 171). Body weight would reflect not only muscles, body fat, and skeletal supports, but also body fluids. MAC and TSF are good indicators of body composition which is influenced by one’s nutritional health status. Body fatness depend upon the levels of one’s physical and metabolic activities, as well as dietary energy intake. When energy-yielding nutrients – fat, carbohydrate, and (if needed) protein – are consumed beyond the body’s needs, the excess is converted to body fat (Whitney 1990: 176-7, 183). Lean body mass, including muscle cells, tissues, and bone mass, depend upon both physical activities and dietary protein intake (Whitney 1990: 399, 407). Physical exercise stimulates gaining strength and size of muscle cells and tissues, as well as the skeletal materials which support muscles. Intake of dietary protein facilitates such changes through provision of the structural materials of muscle and supporting tissues.

Body Mass Index (BMI) is a useful anthropometric indicator which could have been used in this study. BMI is derived from the TSF and MAC values, and is often used to compare adult populations’ energy balance (James et al. 1988: 972-979). BMI was not used, however, because TSF and MAC were considered to be valid indicators of body fat reserve and body protein store respectively, and in these variables seasonal fluctuations

could be traced in millimeters and centimeters.

Morbidity recall data covered three types of illness: diarrhea, fever, and cold. Depending upon the types of illness, epidemiological mechanisms may vary. For example, incidences of fever in Northern Kenya are likely to be a symptom of malaria. Malarial incidents are closely related to the availability of standing water which facilitates breeding of mosquitoes, the causal agent of the disease. Malaria would be uncommon in the desert environments or during the dry seasons, in which the mosquito is absent. In contrast, diarrhea and cold may occur regardless of the water scarcity. Nonetheless, irrespective of types of illness, morbidity rates in general are considered to reflect individuals' reduced resistance to diseases which in turn is a physical symptom of malnutrition, such as energy deprivation or protein deficiency (Whitney 1990: 183).

The six sets of bimonthly repeated measurements of these dietary, morbidity, and anthropometric variables reflect times with varied levels of water and resource availability. Together they characterize the seasonal pattern of dietary and health statuses of the mothers in a normal, non-drought year.

Missing values associated with absences were imputed, through which missing data were filled in with plausible estimates (Solas 1997: 61). The methods of imputation used were as follows. For bounded missing values, that is, when the missing value had both preceding and subsequent values available, the mean value of these two adjacent values was used. For multivariately missing data, that is, when the missing value had only preceding or last value available, that last value was carried forward. For initial values, the subsequent value was replicated. These methods were considered suitable for this study for their ease of implementation as well as the reasonable estimation of the seasonal trends. It should be noted that most imputed data are likely to underestimate the variance,

regardless of the methods (Solas 1997: 61). The imputation methods were chosen with reference to “Missing values in ANOVA” section of Graphpad Prism Help Menu, as well as Solas (1997).

4.2 Methods

Methodological approaches to analyzing these data are three fold. In the first approach the focus was on describing seasonal trends of the dependent variables, e.g. variables included dietary intake, anthropometric values, and morbidity episodes in each community. Independent variables were community (Lewogoso vs. Songa) and season (time).

First of all, a descriptive statistical analysis was conducted to obtain means and standard deviations for the six repeated measurements of the dependent variables for all mothers. Results were then plotted into the time-profile plots in order to facilitate the visual understanding of temporal patterns in the variables (Kuehl 1994: 499-500). These depict the quantitative differences among the variables, as well as the seasonal fluctuation of each variable over time for both communities.

For dietary data, in order to effectively and yet concisely convey the contrasting characteristics in the two communities' diets, instead of presenting all food items one by one, the results for milk and maize, the respective staple food items for Lewogoso and Songa, were plotted first. Then all food items were plotted together as total diet. This way the characteristics of the diets were captured with their seasonality in both food servings and food variety.

Since the dietary recall data could not be quantified in terms of grams, nutrient composition could not be precisely specified. However, it was possible to roughly

characterize mothers' diets in terms of nutritional balance based upon macro nutrients such as protein, carbohydrates, and fat. For example, milk supplies a good amount of protein (3-4 grams protein/100 grams of cow milk or goat milk). Milk also supplies some carbohydrates and fat, but is still low in calories (60-63 Kcal/100 grams). Thus milk was considered as a high-protein, low-calorie food. (The fat content of milk, at least with cattle shows a significant seasonal fluctuation. For example, Nestel (1986) found that dry-season milk had 6 percent milk-fat whereas wet season milk had 4.4 percent. Thus the caloric value of milk fluctuates seasonally although it is still much lower, relative to say the same amount of maize.) Beans, when consumed with grains, tremendously contribute to protein (9 grams protein/100 grams of boiled soybeans for example), and they also supply generous calories mainly from its carbohydrate and fat (180 Kcal/100 grams of boiled soybeans). Thus beans were considered to be high-protein, high-calorie foods. Maize and sugar contribute to carbohydrates. Along with fat, these two are great suppliers of energy (97 Kcal/100 grams of boiled corn or 364 Kcal/100 grams of dry corn meal; 387 Kcal/100 grams of granulated sugar; 921 Kcal/vegetable oils or shortening; 940 Kcal/100grams of mutton tallow). Maize protein requires proper processing for human digestion, as previously mentioned in Chapter 2. Neither does sugar nor fat provide any meaningful amounts of protein. Thus maize, sugar, and fat were considered to be low-protein, high-calorie foods. The interpretation of dietary status, therefore, was based upon these simplified characteristics of the nutritional balance of the food items. (Nutritional information in this section from Kagawa, 2000).

It should be noted that dietary and nutritional status are different. Dietary status is a more narrow assessment than is nutritional status. Dietary status evaluates only what a person eats whereas nutritional status measures what is metabolized. Nonetheless,

dietary status is often used to infer nutritional status of an individual for the logistic difficulty in conducting a full nutritional assessment. In this study, the dietary data is complemented by anthropometric and morbidity data, both of which are influenced by nutritional status of individuals. Together, they supply valid information on nutritional health of the sample population.

For anthropometric, morbidity, and some dietary values, Student T-tests were conducted to test statistically significant differences between communities, with α set at 0.05.

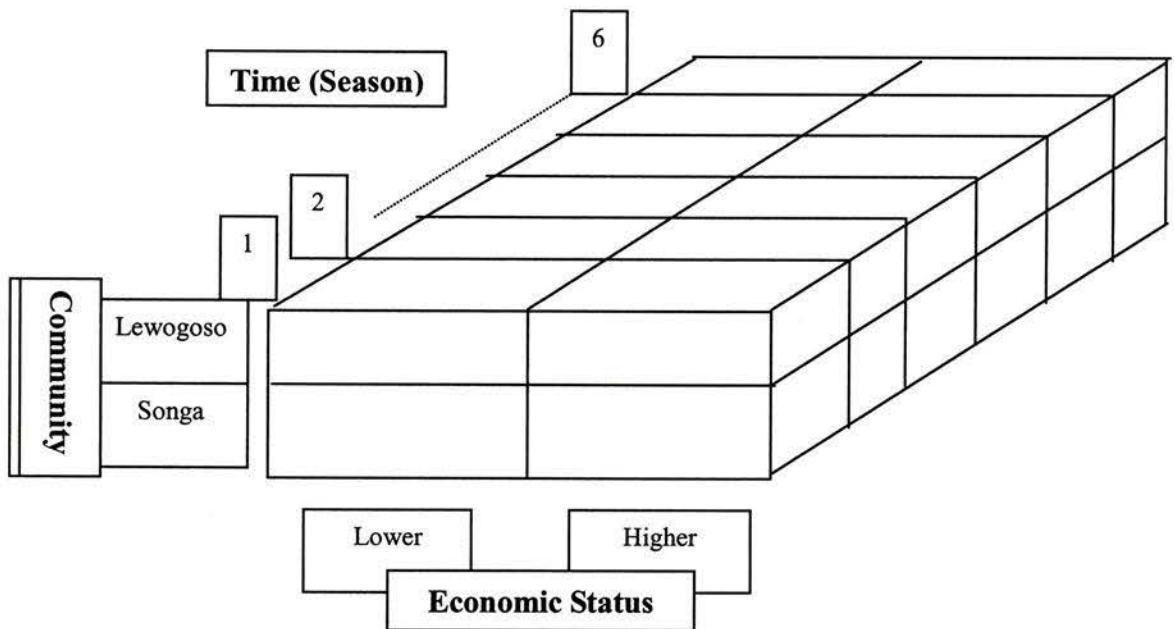
Coefficients of variation were used to assess the degree of temporal variation in dietary, anthropometric, and morbidity values. The coefficient of variation is the ratio of the standard deviation divided by the mean, with which the degree of variations in values is expressed in terms of percentage (Graphpad Prism Version 2.0 1994-5; Kuehl 1994: 18).

In the second approach, the effect of lactation was examined by blocking mothers by lactation status. Independent variables were community (Lewogoso vs. Songa) and season (time). Dependent variable included dietary intake and anthropometric measurements. In order to clarify the effect of lactation in each community, an additional analysis was conducted, for which independent variables were lactation statuses (lactating vs. non-lactating) and season. Dependent variables were dietary intake and anthropometric measurements.

Following this, the third approach employed a repeated measures multivariate analysis of variance (RM-MANOVA) in order to assess the more complex interactions between the community and the economic status over time. Statistical analysis such as MANOVA explains the significance of relationships among the multiple variables

(Iversen 1987; Girden 1992; Kuehl 1994). In this part of the study, independent variables were three-fold: community, time, and economic status. Dependent variables included dietary intake, anthropometric measurements, and morbidity episodes. Figure 4-4 visually clarifies the structure of the analysis. This analysis tells us the contribution of community, economic status, and seasonality on each dependent variable.

Figure 4-4: Conceptual Structure of Repeated Measures Multivariate Analysis of Variance



Independent variables include community, time, and economic status. Dependent Variables are diet, morbidity and anthropometry. In each cell are the mean values for each of the dependent variables of mothers who belong to the corresponding combination of three independent variables. What this analysis will tell us is the contribution of community, economic status and seasonality on dietary intake, anthropometric measurements and morbidity episodes.

The economic statuses in the two communities may not be directly comparable to each other because of the qualitative difference in the respective economic base (i.e. animals vs. land/cash). However, it would still be worthwhile to compare communities in terms of the degree in which economic differences contribute to both inter- and

intra-community differences in diet and health. MANOVA facilitated the examination into how the communities' economic differentiation is manifested in their diet and health.

Statistical analyses were conducted using the SAS System Version 6.12 (1986-1996), including repeated measures MANOVA. Graphs and plots were constructed with the GraphPad Prism Version 2.0 (1994-1995). Prism was also used for some statistical testing (the T-test) and derivation of coefficients of variation.

4.3 Hypotheses

Based upon the above data sets and statistical approaches, the following hypotheses were formulated for testing:

- 1) In both communities, seasonal fluctuations in diet will be reflected in seasonal changes in maternal anthropometric and morbidity patterns.
- 2) Sedentary Songa will feature lower degrees of seasonal fluctuations in dietary intake, anthropometric values and morbidity episodes, relative to those of Lewogoso.
- 3) Songa will feature reduced protein intake than in Lewogoso, as measured by milk and bean intake.
- 4) Songa's mean MAC values will be lower than those of Lewogoso (based upon an assumption that prolonged reduction of protein intake leads to smaller muscle mass).
- 5) Lactating sedentarized mothers will be more vulnerable to protein depletion than lactating nomadic mothers, as measured by anthropometry.
- 6) Independent of community membership, lactating mothers will be more vulnerable to protein depletion than non-lactating mothers in the same community, as measured by anthropometry.

- 7) Sedentism will increase intra-community differences in dietary intake, anthropometric values, and morbidity episodes attributed to economic strata.

Chapter 5

Bivariate Analyses

This chapter discusses the results of bivariate analyses. It consists of two major sections. The first section presents general results of dietary, anthropometric, and morbidity analyses for all mothers, focusing on the seasonal trends. Time-profile plots are presented to visually illustrate the trends. As well, where applicable, statistical testing evaluates between-community differences. These results are then discussed more specifically in the context of hypotheses 1-4. The second section deals specifically with hypotheses 5 and 6, exploring the effects of the lactation status of mothers on their anthropometric statuses. Due to the technical limitation, less emphasis is placed on the seasonal dimensions for the effects of lactation status.

5.1 Central Tendencies for All Mothers

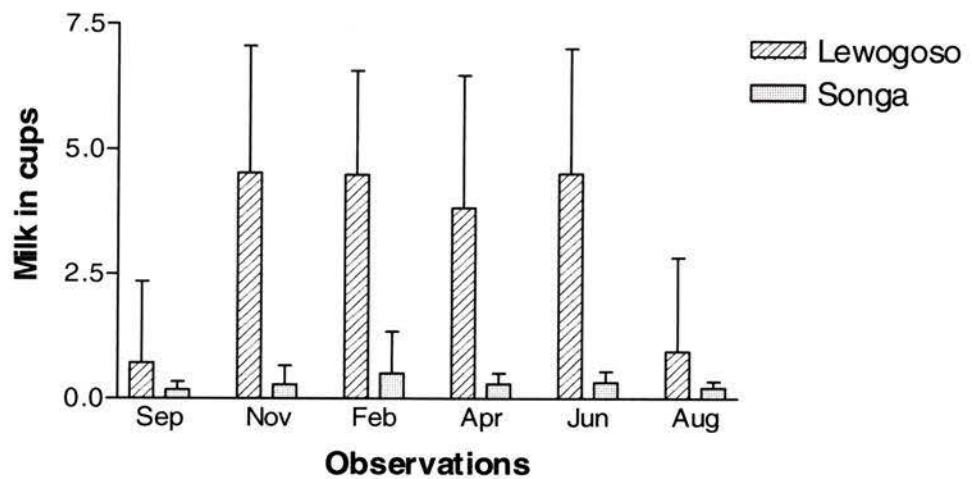
5.1.1 Diet

5.1.1.1 Staple Foods: Milk and Maize

Figure 5-1 shows mean milk intake by community and season. The milk consumption was high in Lewogoso, but it showed a notable seasonal volatility in the quantity, corresponding to the seasonal pattern of rainfall. For example, in November 1994, with the first rain after a drought year (see Figure 4-1: Rainfall), milk consumption skyrocketed in Lewogoso. The high milk consumption continued until June 1995 at the end of the rainy season. The high coefficient of variation for Lewogoso (89.31%) confirms this seasonal volatility. In contrast, mothers in Songa consumed very small amounts of milk with little seasonal volatility, as reflected in the small coefficient of variation (3.99%). The

between-community difference in the milk intake was statistically significant throughout the year. Particularly, the differences between communities during the eight months between November 1994 and June 1995 were highly significant ($p < 0.0001$). Detailed results for the T-tests are summarized in Table 5-1, and coefficients of variation are summarized in Table 5-3.

Figure 5-1
Milk Intake by Community
and Season in 1994-1995

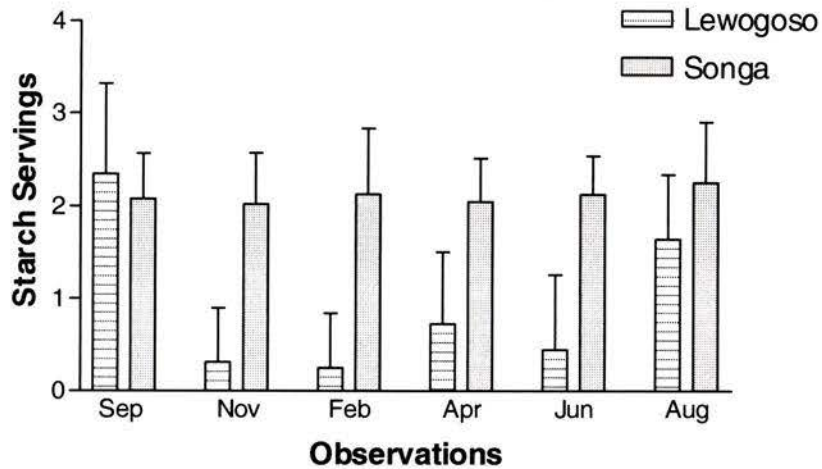


The milk consumption was high in Lewogoso, but it showed a notable seasonal volatility in the quantity, corresponding to the seasonal pattern of rainfall. In contrast, mothers in Songa consumed very small amount of milk throughout the year. Note: In profile plots, bars represent mean values and whiskers signify standard deviation, unless specified otherwise.

**Table 5-1 : Results for the T-test of Milk Intake Differences
between Communities by Season for All Mothers**

Milk	Lewogoso N=40	Songa N=38	T, D.F.	P
September	0.712 ± 0.2585	0.178 ± 0.0265	t=2.004 df=76	0.0486*
November	4.525 ± 0.4005	0.276 ± 0.0624	t=10.23 df=76	<0.0001***
February	4.488 ± 0.3280	0.504 ± 0.1355	t=11.02 df=76	<0.0001***
April	3.825 ± 0.4185	0.289 ± 0.0344	t=8.208 df=76	<0.0001***
June	4.519 ± 0.3949	0.326 ± 0.0344	t=10.31 df=76	<0.0001***
August	0.941 ± 0.2992	0.217 ± 0.0214	t=2.353 df=76	0.0212*

Figure 5-2
Starch Intake by Community and Season
in 1994-1995



Mothers in Songa consumed a large amount of starch throughout the year. In contrast, starch consumed in pastoral Lewogoso was generally small, with the exceptions in September 1994 and again in August 1995.

Instead of milk, starch (mainly from maize) was the most abundantly consumed food in sedentarized Songa. Figure 5-2 shows starch intake by community and season. Mothers in Songa consumed a large amount of starch throughout the year. The mean servings for the year all fell under a narrow range between 2.0 and 2.2 servings per day. The degree of seasonal fluctuations was minor, as reflected in the moderate coefficient of variation: 38.15%. In contrast, starch consumed in pastoral Lewogoso was generally small, with the exceptions in September 1994 and again in August 1995. The bimonthly mean values ranged more widely between 0.25 and 2.35 servings. Accordingly, the degree of seasonal fluctuations was higher as reflected in the elevated coefficient of variation: 57.91% (See Table 5-3). The differences in starch intake between communities were highly statistically significant ($p < 0.0001$) for all assessments except for September 1994 when mothers in both communities consumed roughly equivalent servings of starch. The statistical results for starch intake are summarized in Table 5-2.

Table 5-2: Results for the T-test of Starch Intake Differences between Communities by Season for All Mothers

Starch	Lewogoso N=40	Songa N=38	T, D.F.	P
September	2.350 ± 0.1542	2.079 ± 0.0789	t=1.541 df=76	0.1276
November	0.313 ± 0.0925	2.026 ± 0.0883	t=13.38 df=76	<0.0001***
February	0.250 ± 0.0930	2.132 ± 0.1142	t=12.83 df=76	<0.0001***
April	0.725 ± 0.1240	2.053 ± 0.0749	t=9.051 df=76	<0.0001***
June	0.450 ± 0.1288	2.132 ± 0.0672	t=11.40 df=76	<0.0001***
August	1.650 ± 0.1106	2.263 ± 0.1045	t=4.019 df=76	0.0001***

Table 5-3: Coefficients of Variation for Milk and Starch Intake for All Mothers by Community

Anthropometry	Lewogoso	Songa
Milk	89.31%	3.99%
Starch	57.91%	38.15%

In terms of the respective staple food, Lewogoso's diet appears rich in dietary protein from milk but is highly seasonal, whereas Songa's diet appears more stable and higher in carbohydrates from maize, but lower in dietary protein (Fujita 2000).

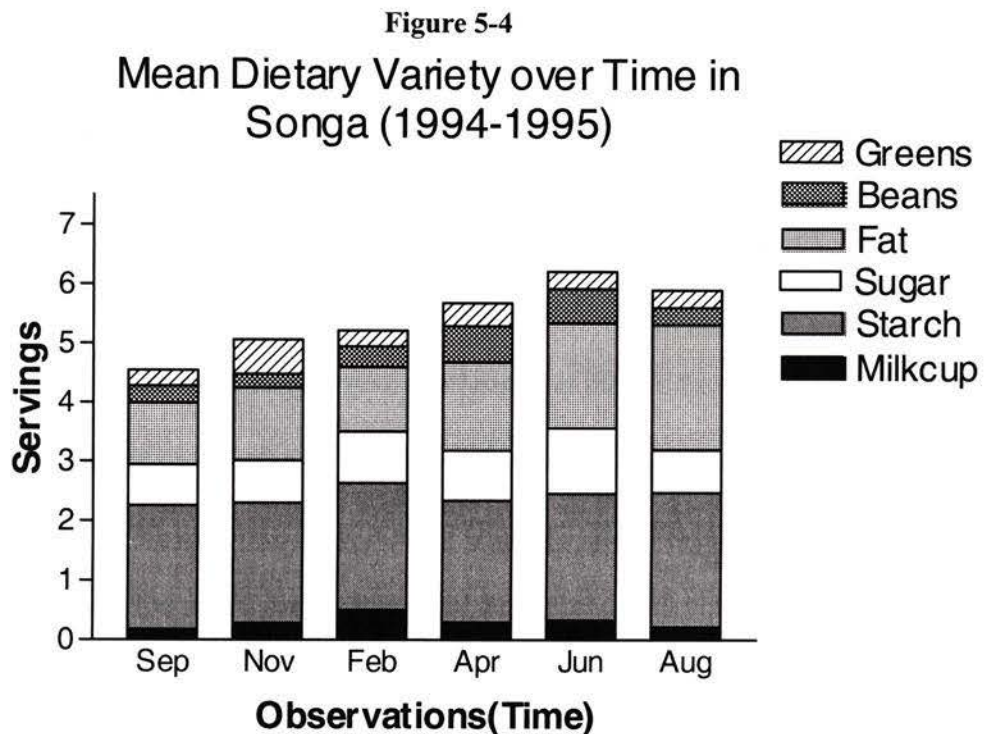
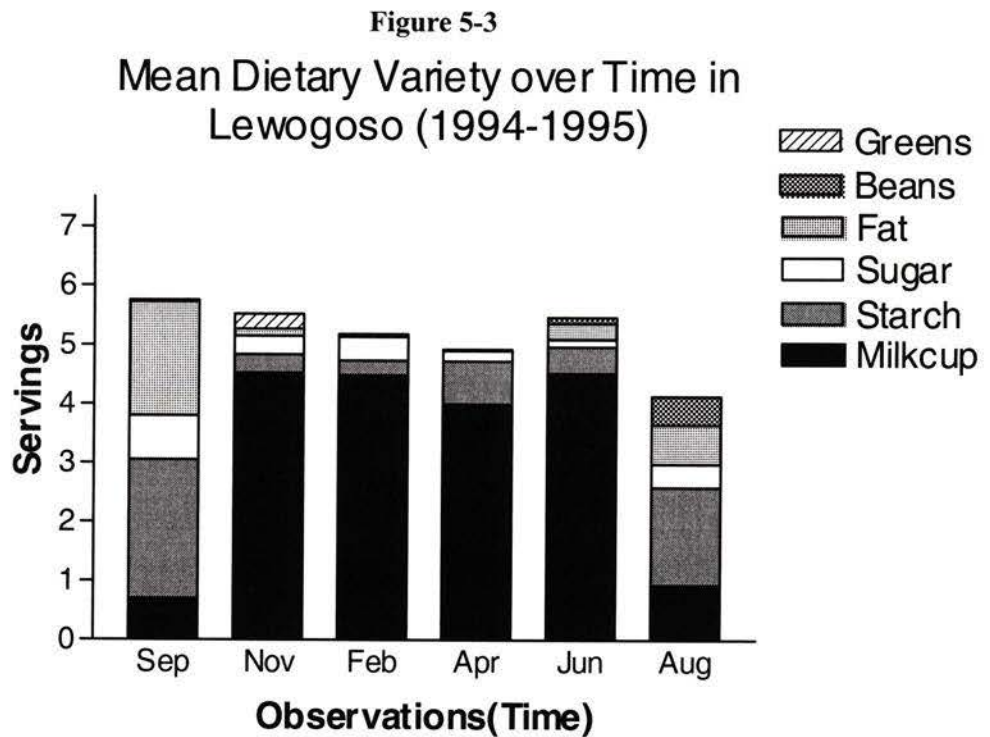
5.1.1.2 All food servings for Lewogoso

Figure 5-3 shows all food servings for Lewogoso. It depicts two separate features of diet at the same time. The first feature is the food variety in diet. Within a bar different food items are depicted as segments. Thus the more segmented a bar is, the more variety of food items there were in the 24-hour dietary recall. The second feature is the total servings of foods in diet, represented by the height of the bars in the graph. This will provide us with some ideas about the food "abundance" or "scarcity" of various food items combined, over time.

As for dietary variety, diet in Lewogoso consisted predominantly of milk (see Figure 5-3). Mothers' diet showed highly volatile food compositions over the course of the year depending upon the availability of milk. Mothers' diet was not highly diversified when milk was abundant.

Although the high volatility in both milk availability and food compositions lead Lewogoso mothers' diet to be characterized as highly seasonal, the fluctuation of the total food servings, or heights of the bars, all fell between 4 and 6 servings per day. This indicates that the degree of seasonal fluctuation was not as striking as it appeared when milk consumption was examined alone (see Figure 5-1). September was the time with the highest food servings, but it was not the most favorable time due to the extreme scarcity of milk and consequently unbalanced nutrition. November 1994 and June 1995 were probably better times with abundant milk as well as with generous total food servings (5.5 servings per day). The leanest time was August 1995 when milk was scarce and the total food servings recorded the lowest of the year (4 servings per day).

As for the nutrition from the total diet, mothers in Lewogoso consumed a lot of protein but not many calories from milk, seasonally supplemented by a host of low-protein, high-calorie foods such as maize, sugar, and fat.



5.1.1.3 All food servings for Songa

Figure 5-4 shows all food servings for Songa. Songa residents mostly consumed maize, sugar, and fat, all of which are high in calories but low in protein. In all six assessments, these three items occupied the overwhelming majority of the mothers' diet. The contributions from milk, beans, and greens remained minor throughout the year. The mothers' diet in Songa showed relatively stable food compositions throughout the year. That is, the similar amounts of food items were available year-round unlike Lewogoso. In this regard, dietary seasonality was considerably reduced in Songa, relative to their nomadic counterparts.

The seasonal fluctuation of the total dietary intake, or heights of the bars, all fell between 4 and 6 servings. September 1994 was the lean time with the least total servings. June 1995 was the best time with the most abundant food servings, including beans, available in the mothers' diet. Interestingly, the degree of fluctuation was equivalent to that in Lewogoso (see Figure 5-3). Thus the difference in dietary seasonality in terms of the bulk, rather than in terms of the nutritional values or variety of diet, appeared less striking.

In terms of nutrition, mothers' diet in Songa provided larger amounts of carbohydrate and fat but much reduced milk protein, relative to Lewogoso. Nonetheless, bean intake contributed more regularly to mothers' diet than in Lewogoso. Since beans consumed with maize can improve the balance of essential amino acids to what is comparable to the high-quality animal protein (Foster 1992: 74) (see Chapter 2), this bean intake may have compensated for the loss of protein associated with reduced milk intake (Fujita 2001). It is also noteworthy that despite its dwindling amounts, milk was recorded in all six recalls in Songa. Thus milk still made small but important contribution to protein

nourishment of mothers in Songa.

In summary, dietary data showed distinct dietary features of the two communities, each with distinct staple food, seasonal patterns, and food variety consumed. The dietary features of the two communities are summarized in Table 5-4.

Table 5-4: Summary of Dietary Features by Community

Dietary Features	<i>Lewogoso</i>	<i>Songa</i>
Best Time	Nov 94 / Jun 95	Jun 95
Lean Time	Sep 94* / Aug 95	Sep 94
Dominant Food Items	Milk	Maize, Fat, Sugar
Nutritional Characteristics	High Milk-Protein, Low Calorie Intake	Lower Milk-Protein, High Calorie Intake
Seasonality	Highly Seasonal Milk Intake and Dietary Variety	Constant Intake of Maize, Sugar, and Fat

* Lean time defined in terms of milk scarcity.

5.1.2 Anthropometry

Table 5-5 summarizes the seasonal aspects of anthropometric indices, focusing on respective peak and base months. The varying peak and base months for the three anthropometric indices indicate that body composition of mothers changed seasonally (i.e., fat reserve and muscle mass fluctuated independently of each other). The following section discusses these seasonal patterns of anthropometric results.

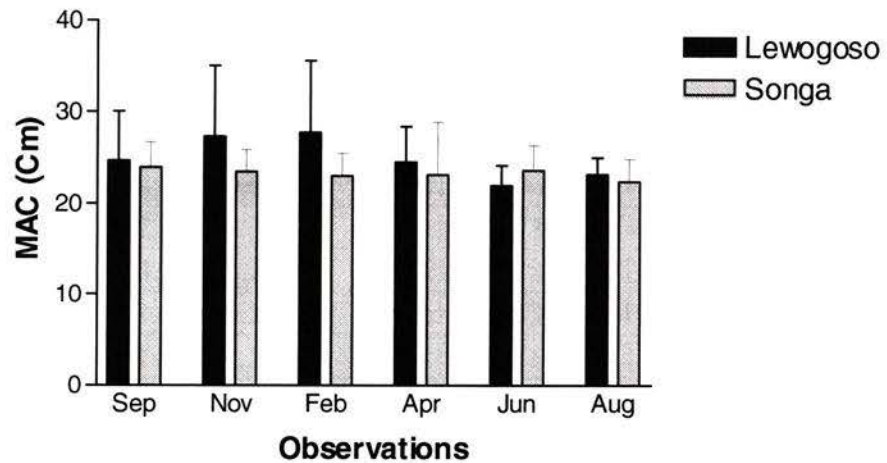
Table 5-5: Peak and Base Months for Anthropometric Status by Community

Anthropometric Indices	Lewogoso		Songa	
	Maximum	Minimum	Maximum	Minimum
MAC	Feb 95	Jun 95	Sep 94	Aug 95
TSF	Apr 95	Jun 95	Nov 94	Aug 95
Weight	Apr 95	Nov 94	Jun 95	Nov 94

5.1.2.1 Mid-upper Arm Circumference (MAC)

Figure 5-5 shows mid-upper arm circumference (MAC) for mothers by community and season. Statistically significant differences between communities were observed on three out of six occasions: November 1994, February 1995, and June 1995 ($t=2.901$, $p=0.0049$; $t=3.482$ $p=0.0008$; and $t=3.015$, $p=0.0035$ respectively). Table 5-6 summarizes the results from the T-tests for anthropometric differences between communities. On the former two occasions, differences were in favor of Lewogoso, as depicted in the taller bars for Lewogoso in Figure 5-5. On the latter occasion, the pattern was reversed, in favor of Songa mothers, as depicted in the taller bar for Songa in the figure.

Figure 5-5
Mean MAC by Community and
Season in 1994 -1995



The MAC values for Lewogoso showed a large seasonal fluctuation. In contrast, the MAC values for Songa all fell in the narrow range

The Figure 5-5 further depicts the seasonal fluctuations in MAC in respective communities. The MAC values for Lewogoso showed a large seasonal fluctuation. In September 1994, the mean MAC in Lewogoso was 24.77 cm, but it rapidly achieved its maximum of 27.78 cm in February 1995. In the subsequent two sessions or four months, MAC continued to decrease at an alarming rate to record 22.04 cm, the lowest value for the year, in June 1995. The value then regained an upward trend between June and August 1995, approaching the original value in September 1994. In a sharp contrast, the MAC values for Songa all fell in the narrow range of between 23.0 (February 1995) and 24.0 cm (September 1994) without large deviations. This contrast between the degrees of fluctuation of MAC in the two communities was also reflected in difference between the coefficients of variation (9.0% for Lewogoso and 2.3% for Songa), as summarized in Table 5-7.

Table 5-6: Results for the T-test of Anthropometric Differences between Communities by Season for All Mothers

Indices	Assessment	Lewogoso (N=40)	Songa (N=38)	T (D.F.=76)	P
MAC	September	24.77 ± 0.8377	24.00 ± 0.4398	t=0.7964	0.4283
	November	27.36 ± 1.230	23.54 ± 0.3853	t=2.901	0.0049**
	February	27.78 ± 1.254	23.09 ± 0.3986	t=3.482	0.0008***
	April	24.59 ± 0.6105	23.21 ± 0.9300	t=1.250	0.2152
	June	22.04 ± 0.3477	23.71 ± 0.4373	t=3.015	0.0035**
	August	23.27 ± 0.2929	22.47 ± 0.4078	t=1.604	0.1130
TSF	September	11.31 ± 0.5181	13.18 ± 0.8123	t=1.968	0.0528
	November	11.66 ± 0.5304	13.90 ± 0.7575	t=2.446	0.0168*
	February	12.08 ± 0.4647	12.06 ± 0.7178	t=0.02327	0.9815
	April	12.87 ± 0.5942	11.97 ± 0.6784	t=1.008	0.3165
	June	10.71 ± 0.4484	11.75 ± 0.6568	t=1.315	0.1926
	August	11.32 ± 0.4967	11.70 ± 0.6867	t=0.4547	0.6506
Weight	September	50.09 ± 0.8541	50.76 ± 0.9356	t=0.5342	0.5948
	November	49.84 ± 0.8073	49.86 ± 0.9195	t=0.02303	0.9817
	February	50.39 ± 0.8898	49.94 ± 0.9200	t=0.3522	0.7257
	April	50.96 ± 0.8193	50.79 ± 0.9300	t=0.1380	0.8906
	June	50.06 ± 0.8175	51.83 ± 0.9700	t=1.406	0.1639
	August	50.81 ± 0.7777	51.52 ± 0.8072	t=0.6368	0.5261

Table 5-7: Coefficients of Variation for Anthropometric Values for All Mothers by Community

Anthropometry	Lewogoso	Songa
MAC	9.00%	2.30%
TSF	6.40%	7.27%
Weight	0.89%	1.58%

5.1.2.2 Triceps Skinfold Thickness (TSF)

Figure 5-6 shows Triceps Skinfold Thickness (TSF) for mothers by community and season. The between-community difference was statistically significant in November 1994, in favor of Songa ($t=2.446$ $p=0.0168$) (see Table 5-6). The two communities had

distinct peak months. Mothers in Lewogoso had the maximum value of TSF in April 1995 (12.87 mm) while mothers in Songa had their maximum TSF in November 1994 (13.90 mm). Still, in terms of temporal variation, the two communities showed similar degrees of fluctuations in TSF, represented by closer coefficients of variation: 6.40% for Lewogoso and 7.27% for Songa, as summarized in Table 5-7.

5.1.2.3 Body Weight

Figure 5-7 depicts weight by community and season. The mean weights were fairly stable for both communities, and there were no significant differences at any particular time of the year (see Table 5-6). The two communities had distinct peak times: April was the heaviest time for mothers in Lewogoso (50.96 Kilograms) and June 1995 was the maximum month for Songa mothers (51.83 Kilograms). Coefficients of variation were both small: 0.89 % for Lewogoso and 1.58 % for Songa (Table 5-7).

Figure 5-6
Mean TSF by Community and Season
in 1994-1995

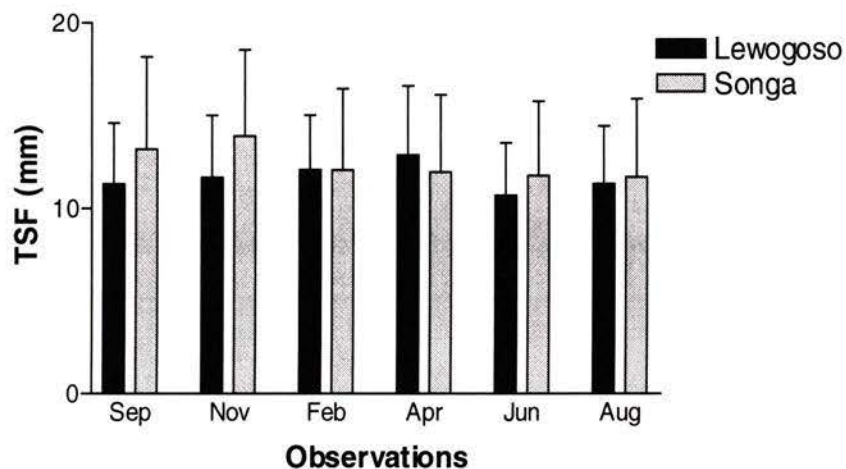
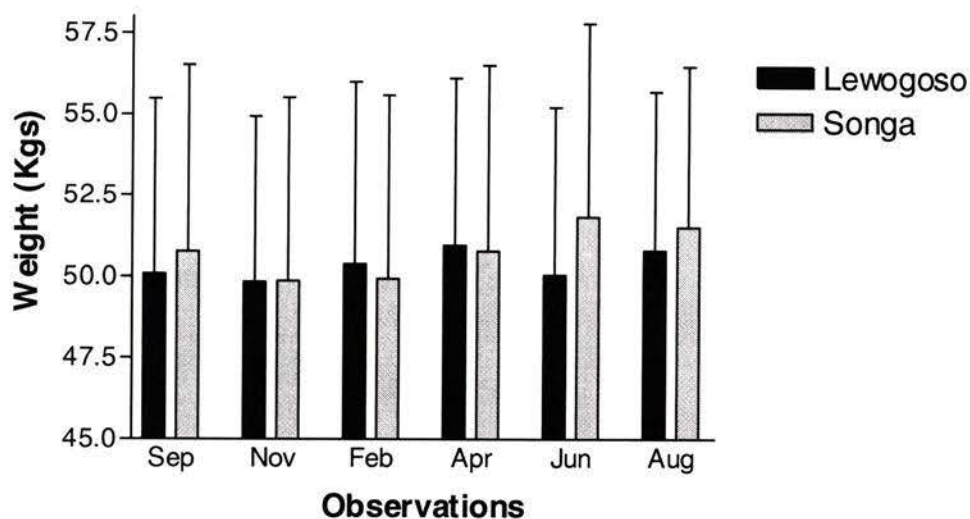


Figure 5-7
Mean Weight by Community and
Season in 1994 - 1995



5.1.3 Morbidity

Most notable about the morbidity was the distinct timing of peak prevalence for respective community. Table 5-8 summarizes the peak months for morbidity by illness and community. Lewogoso's peaks were September 1994 and August 1995 whereas Songa's peaks were February and April 1995, depending upon types of illness, as discussed in the following.

Table 5-8: Peak Months of Morbidity by Type of Illness for All Mothers

Illness Type	Lewogoso	Songa
Diarrhea	Sep 94	Apr 95
Fever	Aug 95	Feb 95
Cold	Sep 94	Apr 95

5.1.3.1 Diarrhea

Figure 5-8 shows mean days of diarrhea in two communities. The episodes of diarrhea in Lewogoso were reported only in two out of six months: September and November 1994. For both these months, the mean days of diarrhea were short: 0.5 and 0.2 days respectively. In contrast, among Songa mothers, diarrhea was prevalent in all six bimonthly recalls, ranging from 0.1 days (September 1994 and August 1995) to 1.0 day (April 1995). The year-round prevalence of diarrhea in Songa may be a negative consequence of sedentism in the sense that Songans were under constant risk of diarrhea.

Figure 5-8

Mean Days of Diarrhea by
Community and Season in
1994-1995

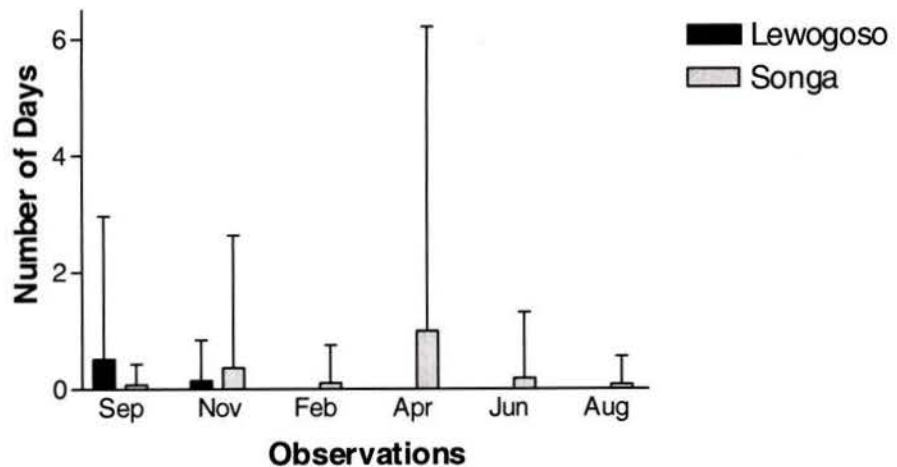
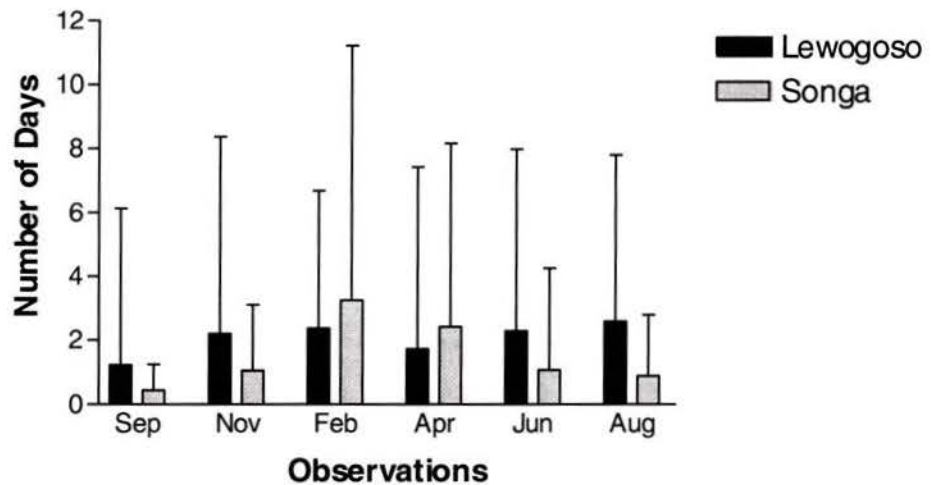


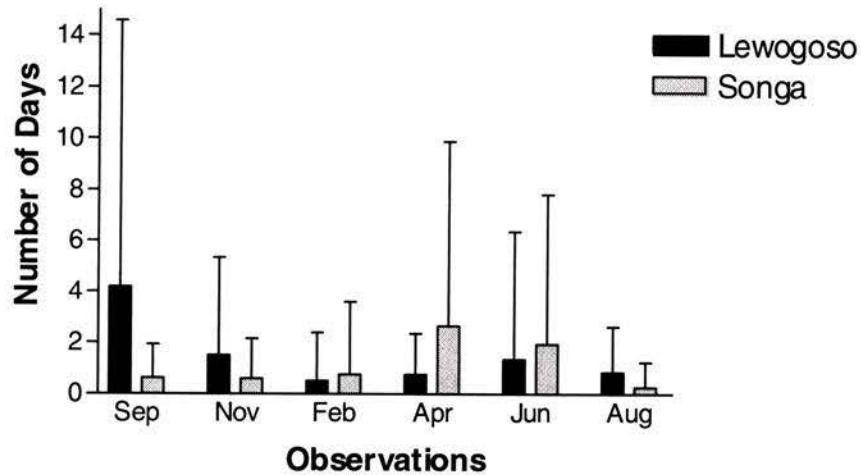
Figure 5-9
Mean Days of Fever
by Community and Season in
1994-1995



5.1.3.2 Fever

Episodes of fever were seen all year round in both communities as Figure 5-9 depicts. In Lewosogo, mean days of fever ranged between 1.2 and 2.6 days with large standard deviations for all six months. In Songa, mean days ranged more widely between 0.5 and 3.3 days. The T-tests, however, indicated that between-community differences in mean days were statistically insignificant for all assessments (results not shown). The difference between communities was rather more apparent in the seasonal patterns of fever. For example, the Lewogoso's peak month was August 1995 (2.6 days) whereas the peak in Songa was February 1995 (3.3 days) (See Table 5-8). In addition to distinct peak months, the two communities had widely differing degrees of fluctuation. As shown in Table 5-10, coefficients of variation for Lewogoso was 24.40% reflecting narrower variation, whereas Songa's coefficient was 70.59%, demonstrating a much higher seasonal variation.

Figure 5-10
Mean Days of Cold
by Community and Season in
1994-1995



5.1.3.3 Colds

Figure 5-10 shows mean days of cold in Lewogoso and Songa. Episodes of cold were also present all year round in both communities. In Lewogoso, mean days of cold varied between 0.5 and 4.2 days with its peak in September 1994. In Songa, mean days of cold varied between 0.3 and 2.7 days. In September 1994, mother in Lewogoso suffered cold significantly ($p=0.0389$, $t=2.102$) longer (4.2 days) than did the mothers in Songa (0.6 days) (see Table 5-9). The variation over time was fairly similar to each other, represented by roughly equivalent coefficients of variation: 88.49% for Lewogoso and 82.05% for Songa (see Table 5-10). The peak time in Songa was in April 1995, clearly different from that in Lewogoso (see Table 5-8).

Table 5-9: Results for the T-test of Morbidity (Colds) Differences between Communities by Season for All Mothers

Illness	Assessment	Lewogoso N=40	Songa N=38	T D.F.=76	P
Colds	September	4.200 ± 1.642	0.632 ± 0.2114	t=2.102	0.0389*
	November	1.500 ± 0.6087	0.605 ± 0.2517	t=1.333	0.1865
	February	0.525 ± 0.2952	0.763 ± 0.4610	t=0.4395	0.6615
	April	0.775 ± 0.2493	2.658 ± 1.173	t=1.608	0.1121
	June	1.350 ± 0.7938	1.947 ± 0.9556	t=0.4828	0.6306
	August	0.850 ± 0.2809	0.263 ± 0.1586	t=1.794	0.0768

Table 5-10: Coefficients of Variation for Morbidity for All Mothers by Community

Illness Type	Lewogoso	Songa
Diarrhea	N/A*	118.56%
Fever	24.40%	70.59%
Cold	88.49%	82.05%

* Coefficients of Variation for diarrhea in Lewogoso is not shown since it was not prevalent all year and thus not comparable to other values.

5.1.4 Understanding the Results in the Context of Hypotheses 1-4

The analyses discussed thus far provide enough information to investigate the first four hypotheses formulated in the previous chapter.

Hypothesis 1

The first hypothesis predicts that in both communities, seasonal fluctuations in diet will be reflected in seasonal changes in maternal anthropometric and morbidity patterns. This hypothesis was supported with regard to anthropometric patterns. As for morbidity patterns, the hypothesis was true only for diarrhea and colds in Lewogoso. Fevers in Lewogoso reflected rainfall patterns, rather than dietary patterns. The morbidity

in Songa reflected neither dietary nor rainfall patterns, regardless of the types of illness.

Hypothesis 1 a) Diet and Anthropometric Patterns

For both communities seasonal fluctuations in diet were reflected in seasonal changes in maternal anthropometric patterns. For example, statistically significant differences in anthropometry, presented in Table 5-6, closely reflected the dietary patterns of the corresponding months. When Lewogoso mothers' consumption of milk showed a big leap toward November 1994, their MAC skyrocketed to significantly exceed that of Songa (see Figure 5-3 for diet in Lewogoso). When mothers in Songa were enjoying the highest food servings including beans, MAC reversed in June in favor of Songa (see Figure 5-4 for diet in Songa). Similarly, when TSF in Songa significantly exceeded that in Lewogoso in November (see Table 5-6), food consumption in Songa (especially those items with high caloric values such as maize, sugar and fat) was increasing, contributing to the mothers' energy reserve and upward TSF trend. On the same occasion, the consumption of high-calorie food items in Lewogoso was replaced by milk, a high-protein but relatively low-calorie item (see Figure 5-3 and 5-4 for diet in Lewogoso and Songa, respectively). These two contrasting dietary patterns toward November appear to have contributed to the widening between-community differences in TSF.

Hypothesis 1 b) Diet and Morbidity Patterns

In Lewogoso, health status of mothers was closely related to the dietary (and rainfall) seasonality. In contrast, Songa's morbidity did not show any obvious relations to dietary patterns (or rainfall patterns). Lewogoso's peak months for diarrhea and cold were both in September 1994, corresponding with the lowest milk-intake by mothers (see Figure 5-8 and 5-10 for diarrhea and cold, respectively, and Figure 5-1 for milk intake). In

Lewogoso, the seasonal pattern of fever was inconsistent with mothers' milk intake. For example, when milk intake increased between September and November 1994, mean days of fever also increased. Still, when milk intake decreased between June and August 1995, episodes of fever still increased to reach its annual maximum (see Figure 5-9 for fever and Figure 5-1 for milk intake). Rather, the seasonal pattern of fever appears more directly related to rainfall pattern (See Figure 2 for rainfall). For example, the two peaks of rainfall, November 1994 and April 1995, were both followed by the increasing prevalence of fever. This association between rainfall and fever might be attributable to the proliferation of water-borne pathogens which cause malaria.

By contrast, in Songa no clear associations between any types of the illnesses and dietary (or rainfall) patterns were found. For example, their dietary intake in general was constantly increasing and improving between September 1994 and June 1995 (See Figure 5-4 for Diet in Songa). Yet, none of the three types of illnesses showed corresponding decreases reflecting supposedly improved dietary status of mothers. Neither were there any recognizable dietary strains in the months with peak prevalence: February 1995 and April 1995 (see Figure 5-8, 5-9, and 5-10 for the three illness types). No apparent association between Songa's morbidity patterns and dietary (or rainfall) seasonality implies the potential influence from other factors. This possibility will be discussed in the final chapter.

Hypothesis 2

The second hypothesis predicts that sedentism will reduce the degrees of seasonal fluctuations in a) dietary intake, b) anthropometric values, and c) morbidity episodes. This hypothesis was true with regard to the dietary intake. As for the anthropometric

measurements, the hypothesis was true only for MAC. As for morbidity, the hypothesis was not supported for any types of illnesses.

Hypothesis 2 a) Sedentism and Dietary Seasonality

The seasonal stress, measured by the degrees of fluctuations in respective staple food, clearly declined in sedentary Songa. In Lewogoso, milk intake was highly volatile whereas in Songa, starch intake showed virtually no seasonal fluctuation (see Figure 5-1 and 5-2 for milk intake and starch intake, respectively). The seasonal stress, defined in terms of the dietary variety, also showed a reduction in Songa. The dietary variety in Lewogoso shifted widely depending upon the seasonal variation of milk (See Figures 5-3 and 5-4 for the diet of respective community). For example, in Lewogoso during November 1994 and June 1995, milk occupied the overwhelming majority of dietary intake, and other foods constituted very small parts. But when milk was scarce in September 1994 and again in August 1995, sugar, maize and fat contributed substantially. In June and August 1995, beans also contributed to Lewogoso mothers' diet. In Songa, such temporal fluctuations in the dietary variety were absent throughout the year.

Hypothesis 2 b) Sedentism and Anthropometric Seasonality

The hypothesis that sedentarization would reduce the seasonality in anthropometry was supported only in terms of MAC. As Table 5-7 indicates, the high volatility in Lewogoso's MAC values was reflected in the larger coefficient of variation (9.0%), compared to the stability in Songa's MAC (coefficient: 2.3%). Both TSF and weight of Songa mothers showed slightly larger coefficients than those of Lewogoso mothers, not supporting the hypothesis.

Hypothesis 2 c) Sedentism and Morbidity Seasonality

Seasonal patterns of morbidity varied by illness type. Irrespective of illness type, however, no support was provided for Songa's reduced morbidity (see Table 5-10 for coefficients of variation). In terms of fever, sedentary Songa showed *increased* seasonal fluctuations, as represented by the elevated coefficient of variation (70.59%) in contrast to that for Lewogoso (24.40%). In terms of cold, the coefficients of Lewosogo and Songa were equivalent to each other (88.49% for Lewogoso and 82.05% for Songa). The coefficient of variation for the prevalence of diarrhea in Lewogoso was considered irrelevant for evaluating the hypothesis because the episodes of diarrhea were present only in two out of six assessments (instead of six out of six), which would overestimate the coefficient. One might argue that diarrhea in Songa was less seasonal in the sense that the illness was prevalent all year long. However, the prominent coefficient of variation for diarrhea in Songa (118.56%) appears to refute this view.

Hypothesis 3

The third hypothesis states that Songa will feature reduced protein intake, as measured by milk and bean intake. Comparison of dietary data from Lewogoso and Songa supports this hypothesis. Consumption of milk in Songa was significantly smaller than that in Lewogoso in all assessments (see Table 5-1). The increased bean intake in Songa in this situation is important since it served as a valid supplement for the reduced milk-protein intake. Still, it would be safe to consider that such supplement, while important, was not substantial enough to completely replace the high level of protein intake in Lewogoso.

Hypothesis 4

The fourth hypothesis states that Songa's MAC values will be lower than those of Lewogoso. The hypothesis was supported when only the first rainy season was considered. As shown in Table 5-6, mothers in Songa recorded significantly smaller MAC values in November 1994 and February 1995. These differences originate in Songa's "loss" of positive variation in MAC during these months, as depicted in Figure 5-5.

Analyses thus far compared all mothers between communities in order to understand the overarching effect of sedentarization on mothers in general. In short, dietary changes were the most striking and defining consequences of the sedentarization. Changes in both anthropometry and morbidity were also noteworthy although they were limited to either specific seasons, types of anthropometric index, or types of illness. Subsequent analyses shift attention to sub-groups of mothers in order to understand how mothers with different circumstances were differently affected by sedentarization.

5.2 Anthropometry by Lactation Status

This section explores the effects of both lactation status and sedentarization specifically on maternal anthropometric statuses. The hypotheses of interest are hypothesis 5 which states that lactating sedentarized mothers will be more vulnerable to protein depletion than lactating nomadic mothers as measured by anthropometry; and hypothesis 6, in which lactating mothers, independent of community membership, are predicted to be more vulnerable to protein depletion than non-lactating mothers in the same community as measured by anthropometry.

Lactation status of samples changed over the course of the year (See Table 4-2).

Thus the seasonal fluctuations of mean values for lactating and non-lactating sub-groups reflected not only the seasonal variation of mothers' nutritional status but also the extraneous variations associated with the changing compositions of lactating and non-lactating sub-groups. Due to the difficulties in controlling this extraneous factor, the analyses in this section focus predominantly on the annual aggregate values and less on the seasonal dimensions.

5.2.1 Lactation Status between Communities

5.2.1.1. Lactating Mothers between Communities

Results from the T-tests for anthropometric values of lactating mothers for the whole year as an aggregate are summarized in Table 5-11. There were no statistically significant differences between communities for any of the three anthropometric indices. Figures 5-11, 5-12, and 5-13 show profile plots for lactating mothers' anthropometry. General trends for lactating mothers were fairly similar to those for all mothers.

Table 5-11: Summary Results for the T-test of Anthropometric Differences between Communities for Lactating Mothers

Anthropometry	Lewogoso	Songa	T, D.F.	P
MAC	25.16 ± 0.9265	23.23 ± 0.2237	t=2.024 df=10	0.0705
TSF	12.22 ± 0.3014	11.90 ± 0.5152	t=0.5347 df=10	0.6046
Weight	50.34 ± 0.2560	49.18 ± 0.6023	t=1.776 df=10	0.1061

Figure 5-11
Mid-upper Arm Circumference (MAC) for Lactating Mothers by Community and Season in 1994-1995

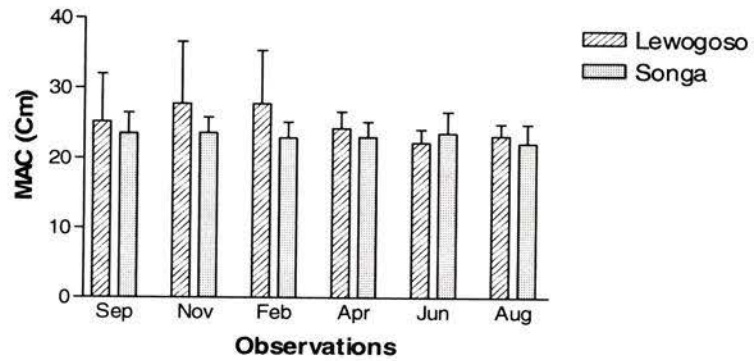


Figure 5-12
Triceps Skinfold Thickness (TSF) for Lactating Mothers by Community and Season in 1994-1995

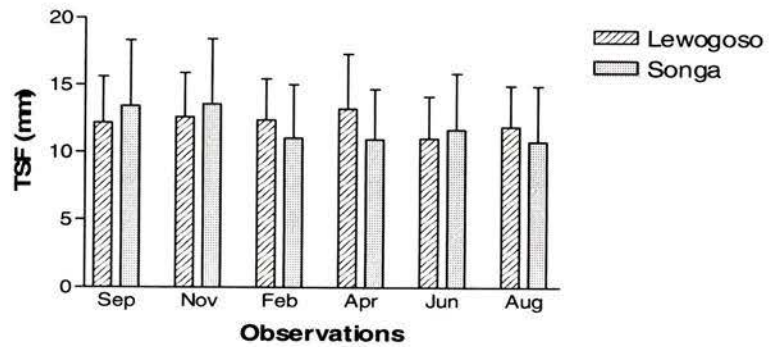


Figure 5-13
Weight for Lactating Mothers by Community and Season in 1994-1995

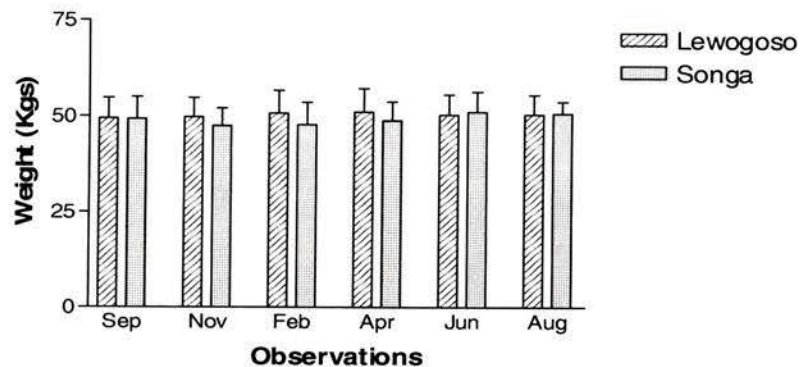


Table 5-12: Results for the T-test of Anthropometric Differences (MAC and TSF) between Communities by Season for Lactating Mothers

Indices	Assessment	Lewogoso	Songa	T, D.F.	P
MAC	September	25.23 ± 1.422 N=23	23.59 ± 0.6230 N=22	t=1.037 df=43	0.3056
	November	27.83 ± 1.892 N=22	23.69 ± 0.4812 N=21	t=2.077 df=41	0.0441*
	February	27.80 ± 1.540 N=25	23.00 ± 0.5372 N=17	t=2.493 df=40	0.0169*
	April	24.38 ± 0.4989 N=22	23.12 ± 0.4755 N=21	t=1.823 df=41	0.0757
	June	22.40 ± 0.4047 N=21	23.68 ± 0.6980 N=19	t=1.630 df=38	<u>0.1115</u>
	August	23.31 ± 0.3658 N=22	22.29 ± 0.6567 N=17	t=1.443 df=37	0.1574
TSF	September	12.16 ± 0.7227 N=23	13.41 ± 1.050 N=22	t=0.9885 df=43	0.3284
	November	12.61 ± 0.7054 N=22	13.55 ± 1.067 N=21	t=0.7369 df=41	<u>0.4654</u>
	February	12.39 ± 0.6143 N=25	11.05 ± 0.9645 N=17	t=1.230 df=40	0.2258
	April	13.23 ± 0.8765 N=22	10.94 ± 0.8214 N=21	t=1.902 df=41	0.0642
	June	11.03 ± 0.6833 N=21	11.67 ± 0.9668 N=19	t=0.5490 df=38	0.5862
	August	11.88 ± 0.6576 N=22	10.77 ± 1.012 N=17	t=0.9572 df=37	0.3447

In contrast to the earlier comparison of MAC and TSF between all mothers, no significant differences were found when lactating mothers were singled out. The underlined P-values indicate the disappearance of significant differences that were present in Table 5-6.

However, when bimonthly values were tested separately, the results were different from those for all mothers. Recall, in the analysis for all mothers in the previous chapter, sedentary Songa mothers' anthropometric values were found significantly larger than those of nomadic Lewogoso mothers in two separate occasions. Specifically, Songa's TSF was larger than that of Lewogoso in November 1994, and Songa's MAC was larger than that of Lewogoso in June 1995. (See Table 5-6). These two differences exemplified the occasions when sedentary mothers were nutritionally better off than nomadic mothers. For lactating mothers, these differences were statistically insignificant. Table 5-12 shows the results of T-tests for MAC and TSF. This suggests that lactating Songa mothers nutritionally benefited less from sedentary life and associated dietary change than did the rest of mothers in the same community (Fujita 2001).

5.2.1.2. Non-lactating Mothers between Communities

When the sub-groups of *non-lactating* mothers from the two communities were compared to each other, pronounced between-community differences emerged. Table 5-13 summarizes the results of T-tests for non-lactating mothers' anthropometry for the whole year. TSF ($p=0.0041^{**}$) and weight ($p<0.0001^{***}$) showed highly significant between-community differences, both in favor of Songa. Figures 5-14, 5-15, and 5-16 depict the profile plots for the three anthropometric indices for *non-lactating* mothers. Both Figures 5-15 and 5-16 visually present the systematic difference, in which Songa's triceps skinfold thickness and weight values consistently exceeded those for Lewogoso throughout the year. These results imply that non-lactating mothers were the sole beneficiaries of sedentism.

Table 5-13: Summary Results for the T-test of Anthropometric Differences between Communities for Non-Lactating Mothers

Anthropometry	Lewogoso	Songa	T, D.F.	P
MAC	24.73 ± 0.9214	23.46 ± 0.2650	t=1.319 df=10	0.2165
TSF	11.22 ± 0.3016	12.92 ± 0.3434	t=3.706 df=10	0.0041**
Weight	50.36 ± 0.2699	52.53 ± 0.1979	t=6.483 df=10	<0.0001***

Figure 5-14
Mid-upper Arm Circumference (MAC) for Non-Lactating Mothers by Community and Season in 1994-1995

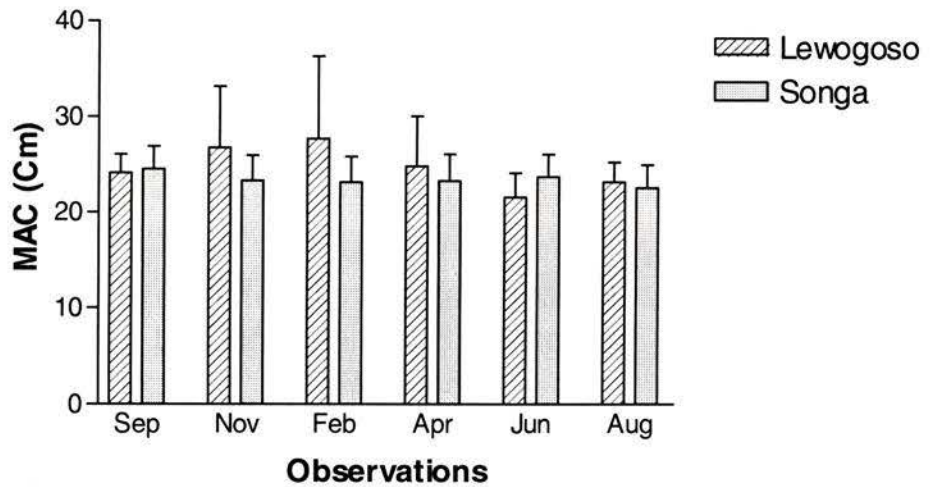


Figure 5-15
Triceps Skinfold Thickness (TSF)
for Non-Lactating Mothers by
Community and Season
in 1994-1995

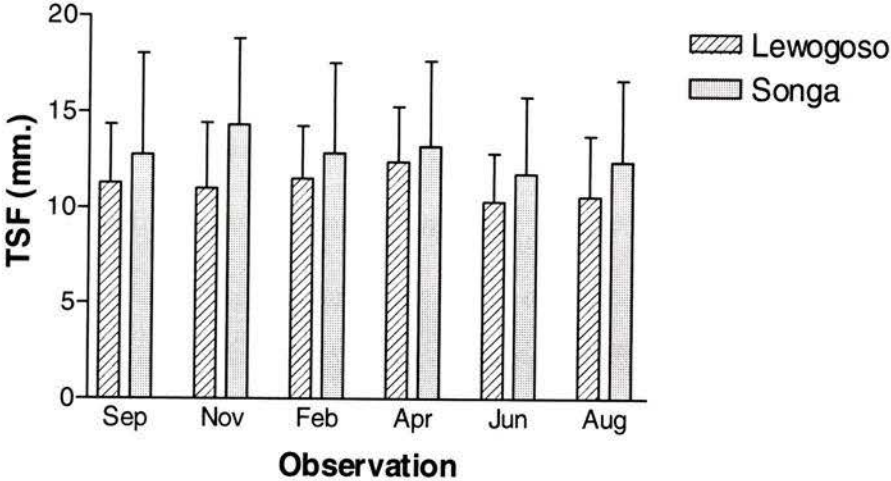
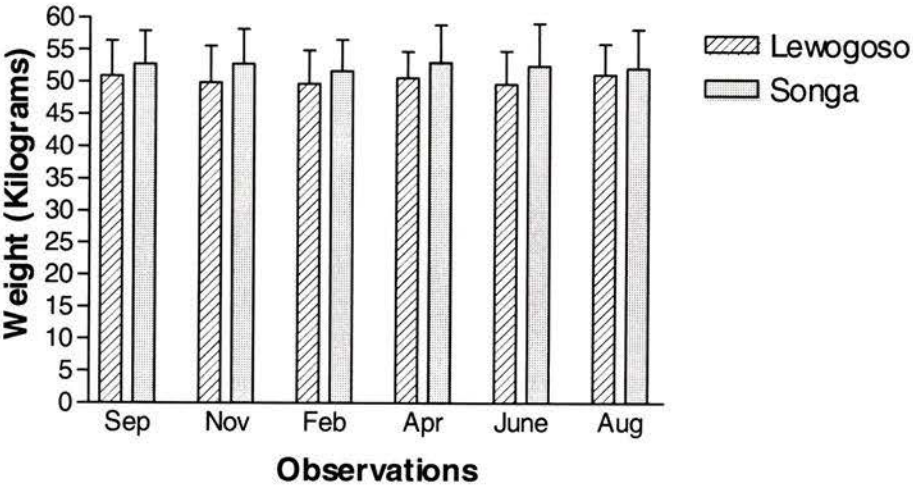


Figure 5-16
Weight for Non-Lactating Mothers
by Community and Season in
1994-1995



A potential confounding factor for these prominent differences might be the anthropometric changes, such as weight gain, associated with pregnancy among non-lactating mothers. Table 5-14 summarizes the prevalence of pregnancy by lactation status. All pregnant mothers but one individual in each community belonged to non-lactating groups. Then the differences in TSF and weight may originate from the higher prevalence of pregnancy among non-lactating mothers. The pregnancy factor can be controlled through excluding pregnant mothers from the non-lactating group. When pregnancy was controlled this way, similarly significant differences were still observed ($t=3.472$, $p=0.006^{**}$ for TSF and $t=4.941$, $p=0.0006^{***}$ for weight), indicating that the lactation status *does* affect health consequences of sedentarization. These results for non-lactating/non-pregnant mothers are summarized in Table 5-15.

Table 5-14: Number of Pregnant Mothers by Lactation Status over Time

Communities Status	Lewogoso		Songa	
	Non-Lactating	Lactating	Non-Lactating	Lactating
September	6	0	6	1
November	5	0	4	1
February	5	0	6	0
April	6	0	3	0
June	8	1	4	0
August	10	0	7	0

Table 5-15 Summary Results for the T-test of Anthropometric Differences between Communities for Non-Lactating, Non-Pregnant Mothers

Anthropometry	Lewogoso	Songa	T, D.F.	P
MAC	24.92 ± 0.6342	23.88 ± 0.3560	$t=1.428$ $df=10$	0.1838
TSF	11.84 ± 0.3086	13.54 ± 0.3804	$t=3.472$ $df=10$	0.0060**
Weight	49.62 ± 0.3391	52.00 ± 0.3446	$t=4.941$ $df=10$	0.0006***

However, the data do not particularly support hypothesis 5 which states that lactating sedentary mothers will be more susceptible to protein depletion than lactating nomadic mothers, as measured by anthropometry. There were no significant anthropometric differences between communities for lactating mothers. Instead, *non-lactating* mothers in Songa recorded significantly higher fat reserve and increased bodyweight than did *non-lactating* mothers in nomadic Lewogoso. These results demonstrate that non-lactating mothers were nutritionally *benefiting* from sedentarization as expressed in their higher TSF and weight values. However, in terms of MAC, which reflect muscle and bone mass (in addition to fat mass), they were not any better off than their nomadic counterparts. This further implies that non-lactating sedentary mothers' body composition was exemplified by significantly enlarged fat reserves (which perhaps contributed to their heavier weight) but unchanged muscle and bone mass, relative to their nomadic counterparts. Such anthropometric patterns might have resulted from their much improved dietary energy intake in Songa, which lead to an increase in fat mass, and reduced protein intake which facilitated little increase in muscle mass.

It is still puzzling, however, why non-lactating mothers alone benefited selectively from sedentarization. Lactating mothers' elevated nutrient requirements for lactation might have offset the benefit from increased energy intake, and consequently kept them thinner and lighter than non-lactating mothers in the same community. Even if this were the case, it does not seem to explain the whole picture. If the lactation factor was the reason for this discriminating pattern, then lactating mothers *in Lewogoso* should have been also thinner and lighter than their non-lactating cohorts. Since the comparison matched the lactation status of mothers in both communities, all mothers in Songa, whether lactating or not,

should have benefited from the increased energy intake. It is unusual that only *non-lactating* mothers benefited from it. In order to better understand the effect of lactation on anthropometric status within community, the remainder of the chapter compares anthropometry of non-lactating and lactating mothers in each community.

5.2.2 Lactation Status within Community

This section examines hypothesis 6 which predicts that lactating mothers, regardless of community membership, will be more susceptible to protein depletion than their non-lactating cohorts. Students T-tests were conducted to compare the anthropometric mean values for non-lactating and lactating mothers of respective community. Table 5-16 summarizes the results for Lewogoso. Astonishingly, in Lewogoso, lactating mothers' TSF was significantly *larger* than that of non-lactating mothers ($t=2.331$, $p=0.0420^*$), indicating the larger fat reserve for lactating mothers. MAC and weight of lactating mothers were roughly equivalent to those of non-lactating mothers. Thus the supposedly elevated energy- and protein-requirements associated with lactation is completely “invisible” in nomadic Lewogoso.

Table 5-16: Summary Results for the T-test of Anthropometric Differences by Lactation Status within Lewogoso

Anthropometry	Non-Lactating	Lactating	T, D.F.	P
MAC	24.73 ± 0.9214	25.16 ± 0.9265	$t=0.331$ $df=10$	0.7477
TSF	11.22 ± 0.3016	12.22 ± 0.3014	$t=2.331$ $df=10$	0.0420*
Weight	50.36 ± 0.2699	50.34 ± 0.2560	$t=0.055$ $df=10$	0.9574

This surprising pattern did not exist in Songa mothers' data (see Table 5-17). In Songa, non-lactating mothers' MAC and TSF values were both slightly larger than that of lactating mothers although these differences were statistically insignificant. However, non-lactating mothers weighed significantly more than lactating mothers ($p=0.0004^{***}$). These results confirm lactating mothers' increased energy expenditure associated with lactation although they do not provide clear support for the lactating mothers' elevated vulnerability – specifically to protein depletion.

Table 5-17 Summary Results for the T-test of Anthropometric Differences by Lactation Status within Songa

Anthropometry	Non-Lactating	Lactating	T, D.F.	P
MAC	23.46 ± 0.2650	23.23 ± 0.2237	$t=0.6696$ df=10	0.5182
TSF	12.92 ± 0.3434	11.90 ± 0.5152	$t=1.646$ df=10	0.1308
Weight	52.53 ± 0.1979	49.18 ± 0.6023	$t=5.288$ df=10	0.0004***

It is indeed curious why lactating mothers had a higher fat reserve in Lewogoso despite their supposedly elevated energy requirement for lactation. Potential explanations may include: 1) lactating mothers in Lewogoso carried out reduced level of physical activities than non-lactating mothers and hence conserved their energy; 2) lactating mothers in Lewogoso consumed more food than non-lactating mothers not only to sustain lactation but also to gain their fat reserve; 3) Lewogoso mothers have some kind of metabolic uniqueness which sustained the energy store of lactating mothers more effectively than that of non-lactating mothers; or the combination of the above.

Figure 5-17
 Intake of All Food Items by
 Season for Non-Lactating Mothers
 in Lewosogo in 1994-1995

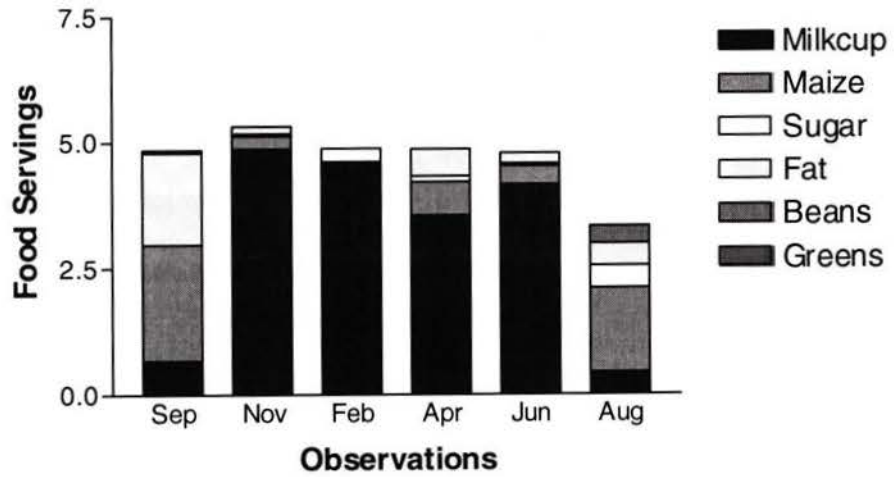
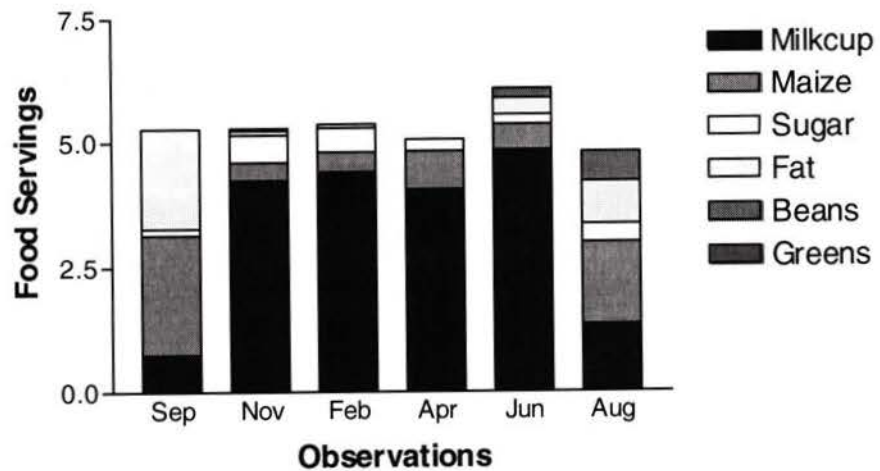


Figure 5-18
 Intake of All Food Items by
 Season for Lactating Mothers in
 Lewosogo in 1994-1995



The first explanation is plausible, but so far no evidence for this was found in the survey of previous ethnographic literature. (Fratkin 1991, 1998; Mitchell 1997; Smith 1997, 1998, 1999; Spencer 1973) The second explanation can be assessed with the dietary data. Figures 5-17 and 5-18 depict Lewogoso's maternal diet for non-lactating and lactating mothers respectively. The dietary servings, and fluctuations appear to be shared by both sub-groups. None of the T-tests for food servings between sub-groups yielded statistically significant results, as summarized in Table 5-18. Thus the dietary recall data do not provide *statistical* support for the second explanation that lactating mothers in Lewogoso ate more. It should be noted, however, that despite its statistical insignificance lactating mothers consumed slightly higher and more constant amount of sugar (0.32 servings, the annual mean) than did non-lactating mothers (0.155 servings). Since sugar offers extremely high, concentrated caloric values, this slight difference could have (although unlikely) lead to the mysterious pattern of lactating mothers' higher fat reserve. Still, without more precise intake measurements which allow caloric calculation, this remains a speculation.

Table 5-18: Summary Results for the T-test of Dietary Differences by Lactation Status within Lewogoso

Food	Non-Lactating	Lactating	T (D.F.=10)	P
Milk	3.051 ± 0.8105	3.276 ± 0.7157	t=0.208	0.8394
Maize	0.874 ± 0.3695	1.015 ± 0.3358	t=0.281	0.7844
Sugar	0.155 ± 0.0689	0.323 ± 0.0682	t=1.730	0.1143
Fat	0.529 ± 0.2719	0.561 ± 0.3152	t=0.078	0.9393
Beans	0.065 ± 0.0545	0.130 ± 0.0972	t=0.582	0.5734

Note: Greens are not included in this table due to its rare appearance in maternal diet in Lewogoso, which in turn prohibited any meaningful statistical testing.

The third metabolic explanation is also a possibility. Researchers such as Little, Leslie, and Campbell (1992); Miller and Huss-Ashmore (1989); Prentice et al. (1981); Shell-Duncan (2000); Shell-Duncan et al. (2001); Winikoff (1983); Winkvist et al. (1992) have explored the metabolic uniqueness of some non-Western mothers, known as maternal depletion syndrome, generally defined as parity-related energy depletion. This syndrome is in a sharp contrast to what women in the industrial- and post-industrial nations typically go through by gaining their body fat with ascending age and parity (Little, Leslie, and Campbell 1992; Winkvist et al. 1992). As mentioned in Chapter 4, the mean age of non-lactating samples was approximately 3 years older than lactating samples in both communities (See Table 4-3). This age difference may have captured the manifestation of maternal depletion in terms of the lower fat reserve of “older” non-lactating mothers only in pastoral Lewogoso where energy intake was limited (assuming older mothers tend to have higher parity although this may not necessarily be true). Since potential contributing factors to maternal depletion include combined effects of heavy workloads and inadequate dietary intake (Shell-Duncan 2000; Shell-Duncan et al. 2001), Songa’s improved dietary energy intake could have reduced the mothers’ energy deficits, and consequently “eased” the depletion. Similar example was documented among Turkana mothers by Little, Leslie, and Campbell (1992: 735), in which nomadic mothers showed much stronger parity-related losses in their adiposity than did settled mothers. While recognizing this as a possibility, however, this explanation cannot be explored further. The evidence is still inconclusive as to whether or not maternal depletion is in fact a phenomenon that can be generalized beyond a particular group or population (Prentice et al. 1981; Winkvist et al. 1992). As well, the metabolic mechanisms for maternal depletion may not be parity-related (Miller and

Huss-Ashmore 1989; Prentice et al. 1981: 2790; Shell-Duncan 2000; Shell-Duncan et al. 2001; Winikoff 1983: 244) or reproduction-related (Shell-Duncan 2000; Shell-Duncan et al. 2001: 26). Moreover, this thesis does not have the information on these mothers' reproductive history, which is necessary for assessing this explanation.

To summarize the within community comparison, no support was provided for hypothesis 6 which predicts lactating mothers to be more vulnerable to protein depletion than their non-lactating cohorts, independent of community membership. Further, the comparison between sub-groups of non-lactating and lactating mothers within Lewogoso revealed a surprising and mysterious pattern, in which lactating mothers recorded higher fat reserves than did their non-lactating cohorts. Regardless of the specific mechanisms for this pattern, the community of Lewogoso appears to have provided effective shelters for its lactating mothers, protecting them from nutritional stress associated with lactation. The absence of such a pattern in Songa may be considered as a consequence of sedentarization, in which this unique shelter for lactating mothers was lost.

Chapter 6

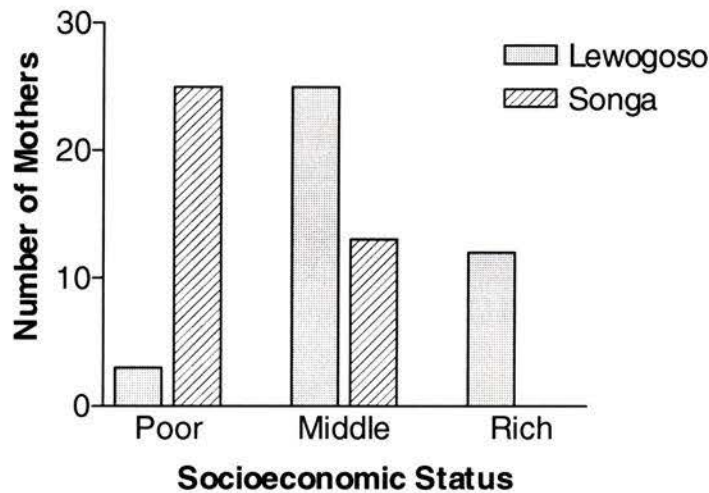
Economic Status

6.1 Economic Distribution

Bivariate exploratory analyses in the previous chapter revealed the key characteristics of mothers' data. This chapter builds upon this foundation and incorporates the socioeconomic variable in the analyses. Using multivariate repeated measures analyses of variance (MANOVA-RM) technique, this chapter attempts to understand whether or not economic status of mothers might have influenced the dietary and nutritional health consequences of sedentarization. Profile plots are also used whenever visual aid assists the clarification of the results.

Samples were assigned to one of the three economic strata – poor, middle, and rich, based upon the composite measure of household wealth, livestock holding, wage income, remittances and household expenditures (Fratkin and Smith 1995). Figure 6-1 shows the economic distribution of the samples. The economic composition of the samples showed a binary distribution in both communities. However, there was a crucial difference between the communities. About 2/3 of Songa mothers were in the poor stratum, and 1/3 was in the middle stratum. Further, Songa showed a complete loss of rich stratum. In contrast, over 2/3 of Lewogoso mothers were in the middle stratum, and 1/3 was in the rich stratum. There were only three mothers from the poor stratum in Lewogoso.

Figure 6-1
Sample Composition by
Socioeconomic Status



Econ.	Lewogoso	Songa
Poor	3.0	25.0
Middle	25.0	13.0
Rich	12.0	0.0

These distribution patterns were originally interpreted as the evidence that samples from nomadic Lewogoso were economically better off than those from settled Songa (Fujita 2000). However, as previously mentioned in Chapter 4, the economic well-being of mothers from the two communities may not be comparable because of the qualitative difference in the respective economic base. For nomads “wealth” consists of livestock, but for the sedentarized it consists of land or cash. Thus simply saying that one community is better or worse than the other does not offer much insight.

Still, the classification of mothers by economic status within each community was considered not only valid but also important because such a factor would potentially influence the mothers’ diet and health. Economic status as a factor is especially relevant as it relates to dietary protein, access to which may depend upon both seasonal scarcity of

milk as well as the economic status of individuals reflecting the relative high cost of dietary protein (see Chapter 3). This chapter, therefore, compares the two communities in terms of the *degree* to which the economic differences influenced intra-community differences in diet and health over time.

This comparison is set within the context of hypothesis 7 which proposes that sedentism will increase intra-community differences in a) dietary intake, b) anthropometric values, and c) morbidity episodes attributed to economic strata. Repeated measures multivariate analysis of variance (RM-MANOVA) allowed examination of these statements.

The statistical model used for the analysis was multivariate repeated analysis. In multivariate repeated analysis, statistical inquiries are two-fold: First, the comparison of treatment groups (economic strata) and second, the comparison within the repeated measures. In statistical terms, the former aspects are referred to as between-subjects effects while the latter are referred to as within-subject effects (Khattree et al. 1999: 178; ACITS 1997: 13). The hypothesis tested in this analysis also consisted of two aspects: 1) whether or not sedentism increased the differences in diet, anthropometry and morbidity attributed to economic strata, and 2) whether or not such differences depended upon seasonality. The former aspect can be tested in the between-subjects (between-economic strata) effects. The latter can be tested in the within-subject by between-subjects interaction effects, or more plainly, the interaction effects of time and economic difference (hereinafter TIME*ECON effects or interaction effects).

For this analysis, the poor stratum of Lewogoso was excluded because it consisted of only three mothers. Statistical results for this stratum were considered likely

to be artifacts of the small sample size of this stratum. In addition, for a statistical comparison, it is desirable to have an equal number of economic strata in the two communities. This allowed more meaningful and clearer comparison, not only for the statistical procedure but also for the interpretation of the results.

6.2 Diet by Economic Status

Table 6-1 shows the results from the test of the hypothesis for between-subjects (between-economic strata) effects for diet in Lewogoso. None of the P-values indicated significant results, suggesting that economic difference in Lewogoso did not significantly influence the intake levels of any food items.

Table 6-1
Summary Results for General Linear Models Procedure
Repeated Measures Analysis of Variance: Tests of Hypotheses for Between-Subjects
(Between-Economic Strata) Effects for Dietary Intake in Lewosogo
(without poor stratum)

Food	Sources	DF	Type III SS	Mean Square	F Value	Pr > F
Milk	Econ	1	20.8057	20.80560	2.59	0.1162
	Error	35	280.7156	8.02044		
Starch	Econ	1	0.0038	0.00384	0.00	0.9442
	Error	35	27.1178	0.77479		
Sugar	Econ	1	0.0937	0.09370	0.24	0.6280
	Error	35	13.7261	0.39217		
Fat	Econ	1	0.8721	0.87208	1.62	0.2113
	Error	35	18.8261	0.53788		
Beans	Econ	1	0.4865	0.48648	3.41	0.0735
	Error	35	5.0000	0.14285		
Greens	Econ	1	0.0022	0.00216	0.47	0.4962
	Error	35	0.1600	0.00457		

Table 6-2
Summary Results for General Linear Models Procedure
Repeated Measures Analysis of Variance: Tests of Hypotheses for Between-Subjects
(Between-Economic Strata) Effects for Dietary Intake in Songa

Food	Sources	DF	Type III SS	Mean Square	F Value	Pr > F
Milk	Econ	1	0.0662	0.0662	0.35	0.5576
	Error	36	6.8025	0.1889		
Starch	Econ	1	0.0863	0.0863	0.23	0.6314
	Error	36	13.282	0.3689		
Sugar	Econ	1	0.9620	0.9620	2.39	0.1310
	Error	36	14.4984	0.4027		
Fat	Econ	1	2.1056	2.1056	3.52	0.0686
	Error	36	21.5128	0.5975		
Beans	Econ	1	8.7452	8.7452	24.56	0.0001
	Error	36	12.8205	0.3561		
Greens	Econ	1	8.6802	8.6802	15.35	0.0004
	Error	36	20.3548	0.5654		

Table 6-2 shows the results for Songa. In contrast to Lewogoso, diet in Songa was influenced by one's economic status. Specifically, two food items – beans and greens – were highly differentiated by mothers' economic status ($Pr < 0.001$ for both). Figure 6-2 and 6-3 show profile plots for beans and greens intake by economic status in Songa, respectively. These figures clearly show a large economic difference between the strata, confirming the RM-MANOVA results. On average, mothers in the middle stratum had access to reasonable amounts of both beans (0.3-1.0 servings) and greens (0.5-1.4 servings). Poor mothers, however, consumed less than a half of these servings (0.1-0.4 servings of beans and 0.1-0.6 servings of greens). Taken together, these results support hypothesis 7 a), specifically for the two food items: beans and greens.

Figure 6-2
 Bean Intake by Economic Status in
 Songa in 1994-1995

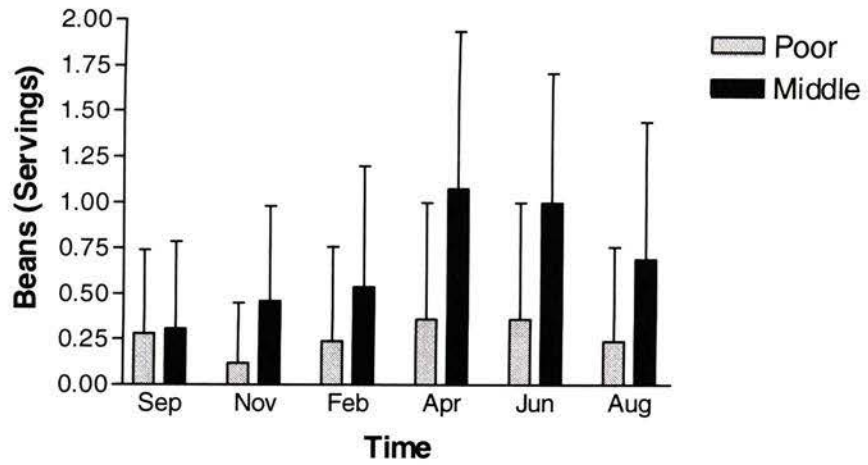
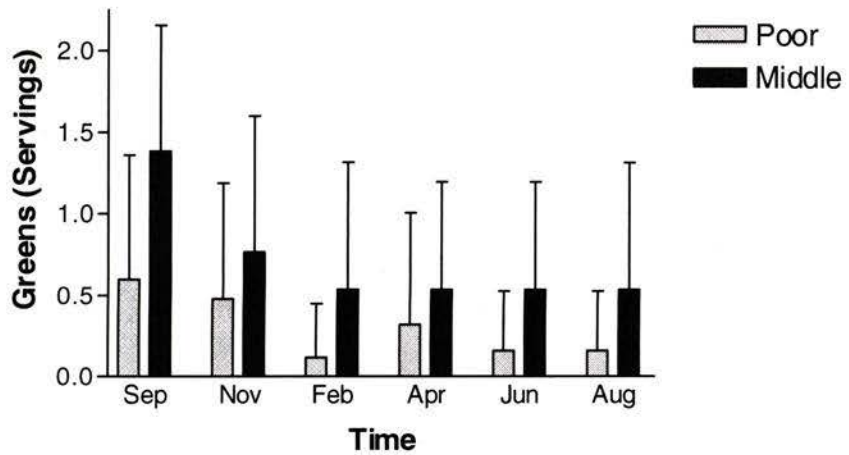


Figure 6-3
 Greens Intake by Economic Status
 in Songa in 1994-1995



The results further provide a piece of cautionary evidence for the previously mentioned point (Chapter 5) that increased bean intake in Songa may have compensated for the loss of milk protein in their diet. This may have been true only for mothers who were economically better off. The poor may have been exposed to low-protein diets, in which little alternative sources of protein were available to compensate for the reduction of milk protein. Further, since over 2/3 of Songa mothers belong to the poor stratum, the majority of Songa mothers may have been at risk of protein deficiency.

Table 6-3 shows the results from the test of the hypothesis of no TIME*ECON interaction effects for Lewogoso. In Lewogoso, only starch intake was simultaneously influenced by both economic difference and seasonality ($P > 0.0403$). Figure 6-4 shows time profile plots for Lewogoso's starch consumption by economic status. The differences between the profiles of the two economic strata noticeably varied but non-systematically depending upon the time of the year, providing a visual confirmation for the results from RM-MANOVA for the interaction effects. This probably reflects the highly seasonal characteristic of nomadic mothers' diet. However, it also implies the presence of the seasonal differentiation of dietary patterns attributed to economic status among nomadic mothers, revealing an extra dimension to the nomadic mothers' food customs aside from their "egalitarian" milk-sharing.

Table 6-4 shows the results for Songa. No statistically significant TIME*ECON effects on any of the food items were found. The absence of significant interaction effects in Songa's diet indicates that the effects of economic status on dietary intake did not depend upon the time of the year, probably reflecting the generally reduced dietary seasonality in Songa, as discussed in Chapter 5.

Table 6-3
Summary Results for General Linear Models Procedure
Repeated Measures Analysis of Variance for Dietary Intake in Lewogoso
(without the poor stratum)

Repeated Measures Level Information

Dependent Variables: Milkcup1-Milkcup6, Starch1-Starch6, Sugar1-Sugar6,
 Fat1-Fat6, Beans1-Beans6, and Greens1-Greens6
 Level of TIME: 1 2 3 4 5 6

Manova Test Criteria and Exact F Statistics for the Hypothesis of no TIME*ECON Effect
 H= Type III SS&CP Matrix for TIME*ECON, E= Error SS&CP Matrix

Food	Hypothesis Tested	Value	F	Num. DF	Den DF	Pr > F
Milk	Time*Econ	0.9601	0.2565	5	31	0.9327
Starch	Time*Econ	0.6986	2.6740	5	31	0.0403
Sugar	Time*Econ	0.7625	1.9304	5	31	0.1176
Fat	Time*Econ	0.8514	1.0814	5	31	0.3899
Beans	Time*Econ	0.8580	1.8196	3	33	0.1628
Greens	Time*Econ	0.9866	0.4730	1	35	0.4962

S=1 M=1.5 N=14.5 Statistic=Wilks' Lambda

Figure 6-4
Starch Intake by Economic Status
in Lewogoso in 1994-1995

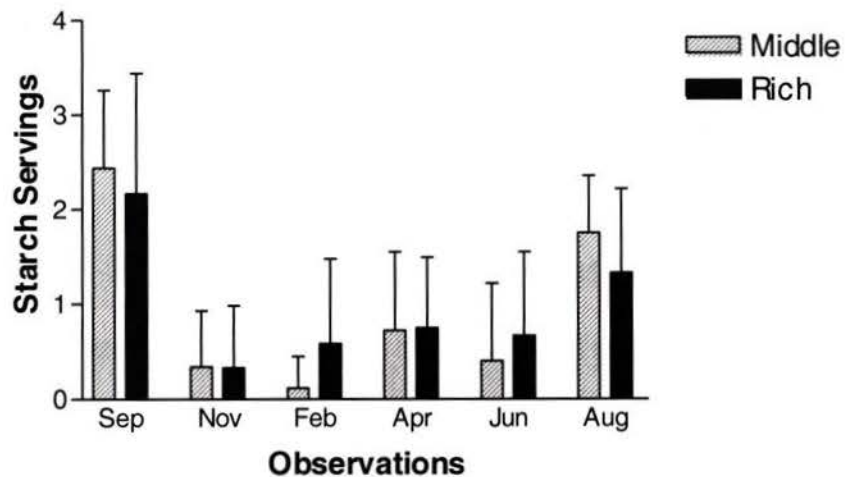


Table 6-4
Summary Results for General Linear Models Procedure
Repeated Measures Analysis of Variance for Dietary Intake in Songa

Repeated Measures Level Information

Dependent Variables: Milkcup1-Milkcup6, Starch1-Starch6, Sugar1-Sugar6,
 Fat1-Fat6, Beans1-Beans6, and Greens1-Greens6
 Level of TIME: 1 2 3 4 5 6

Manova Test Criteria and Exact F Statistics for the Hypothesis of no TIME*ECON Effect
 H= Type III SS&CP Matrix for TIME*ECON, E= Error SS&CP Matrix

Food	Hypothesis Tested	Value	F	Num. DF	Den DF	Pr > F
Milk	Time*Econ	0.9618	0.2541	5	32	0.9346
Starch	Time*Econ	0.9192	0.5623	5	32	0.7280
Sugar	Time*Econ	0.8917	0.7769	5	32	0.5737
Fat	Time*Econ	0.9514	0.3264	5	32	0.8933
Beans	Time*Econ	0.7811	1.7925	5	32	0.1426
Greens	Time*Econ	0.8959	0.7430	5	32	0.5971

S=1 M=1.5 N=15 Statistic=Wilks' Lambda

6.3 Anthropometry by Economic Status

Tables 6-5 and 6-6 summarize the results for the test of hypotheses for between-subjects (between-economic strata) effects for anthropometry. None of the anthropometric indices – MAC, TSF, of weight – showed significant differences between economic strata in either community. This implies that sedentarization did not lead to the differentiation of mothers' anthropometric values attributed to their economic status.

The results for TIME*ECON interaction effects for Lewogoso are summarized in Table 6-7. The test produced a significant result only for MAC ($P>0.0359$) in Lewogoso. This indicates that in Lewogoso, the influence of economic difference upon MAC depended upon the season of the year. Figure 6-5 shows profile plots for MAC by economic status for Lewogoso. The seasonal fluctuations of MAC for the rich and middle economic strata featured distinct patterns, visually confirming the presence of the TIME*ECON interaction effects. For example, the rich stratum began the year with a

relatively low value. This led to a steep upward trend that continued for the subsequent four months to reach its maximum (31.33 cm) by February 1995. The value then declined steeply for the subsequent four months to record its minimum (22.34 cm) in June 1995, followed by a slight upward trend toward August 1995. In contrast, the middle stratum began the year with a relatively high value with an upward trend that approached quickly to the maximum value (27.08 cm) in November 1994. Then the trend shifted downward which prolonged for the subsequent eight months until June 1995 when MAC recorded its minimum value (22.02 cm). This was followed by a slight upward trend toward August 1995. The coefficients of variation for MAC also varied by economic strata, indicating there were economically differentiated degrees of seasonal fluctuations. The rich stratum's coefficient of variation was at 14.64% whereas the middle stratum's coefficient was 7.62%. The higher coefficient for the rich appears to have originated in the *positive* variation during November 1994 and February 1995 as seen in the large hump in the profile. The fact that the differences in MAC were significant but not those for TSF implies that rich mothers in Lewogoso gained their lean body mass benefiting from the increased rainfall and consequent milk availability.

Table 6-5
Summary Results for Repeated Measures Analysis of Variance: Tests of Hypotheses for
Between-Subjects (Between-Economic Strata) Effects for Anthropometry in Lewogoso
(without poor stratum)

Anthropometry	Sources	DF	Type III SS	Mean Square	F Value	Pr > F
MAC	Econ	1	20.6772	20.6772	0.49	0.4901
	Error	35	1487.2948	42.4941		
TSF	Econ	1	66.2609	66.2609	1.54	0.2227
	Error	35	1504.5332	42.9866		
Weight	Econ	1	6.7040	6.7040	0.05	0.8261
	Error	35	4788.5330	136.8152		

Table 6-6
Summary Results for Repeated Measures Analysis of Variance: Tests of Hypotheses for
Between-Subjects (Between-Economic Strata) Effects for Anthropometry in Songa

Anthropometry	Sources	DF	Type III SS	Mean Square	F Value	Pr > F
MAC	Econ	1	3.9527	3.9527	0.14	0.7144
	Error	36	1045.8462	29.0512		
TSF	Econ	1	0.6215	0.6215	0.01	0.9336
	Error	36	3177.9772	88.2771		
Weight	Econ	1	12.2256	12.2256	0.07	0.7882
	Error	36	6005.8630	166.8295		

Table 6-7
Summary Results for General Linear Models Procedure
Repeated Measures Analysis of Variance for Anthropometry in Lewogoso
(without the poor stratum)

Repeated Measures Level Information

Dependent Variables: MAC1 MAC2 MAC3 MAC4 MAC5 MAC6
 TSF1 TSF2 TSF3 TSF4 TSF5 TSF6
 Weight1 Weight2 Weight3 Weight4 Weight5 Weight6
 Level of TIME: 1 2 3 4 5 6

Manova Test Criteria and Exact F Statistics for the Hypothesis of no TIME*ECON Effect
 H= Type III SS&CP Matrix for TIME*ECON, E= Error SS&CP Matrix

Anthropometry	Hypothesis Tested	Value	F	Num. DF	Den DF	Pr > F
MAC	Time*Econ	0.6924	2.7541	5	31	0.0359
TSF	Time*Econ	0.7975	1.5734	5	31	0.1967
Weight	Time*Econ	0.7777	1.7712	5	31	0.1480

S=1 M=1.5 N=14.5 Statistic=Wilks' Lambda

In Songa, none of the anthropometric indices were subjected to the interaction effects, as shown in Table 6-8. Again, this probably reflects Songa's generally reduced seasonal variations in anthropometric values, as previously discussed in Chapter 5. Figure 6-6 shows MAC profiles by economic status in Songa. Seasonal fluctuations for both strata in Songa were much reduced. Both profiles appear to have little relation to the dietary seasonality. Further, there were few economic differences in MAC values, confirming the results from RM-MANOVA.

Table 6-8
Summary Results for General Linear Models Procedure
Repeated Measures Analysis of Variance for Anthropometry in Songa

Repeated Measures Level Information

Dependent Variables: MAC1 MAC2 MAC3 MAC4 MAC5 MAC6

TSF1 TSF2 TSF3 TSF4 TSF5 TSF6

Weight1 Weight2 Weight3 Weight4 Weight5 Weight6

Level of TIME: 1 2 3 4 5 6

Manova Test Criteria and Exact F Statistics for the Hypothesis of no TIME*ECON Effect

H= Type III SS&CP Matrix for TIME*ECON, E= Error SS&CP Matrix

Anthropometry	Hypothesis Tested	Value	F	Num. DF	Den DF	Pr > F
MAC	Time*Econ	0.8887	0.8008	5	32	0.5574
TSF	Time*Econ	0.9373	0.4277	5	32	0.8259
Weight	Time*Econ	0.8558	1.0783	5	32	0.3909

S=1 M=1.5 N=15 Statistic=Wilks' Lambda

Figure 6-5
Mean MAC by Economic Status
in Lewogoso in 1994-1995

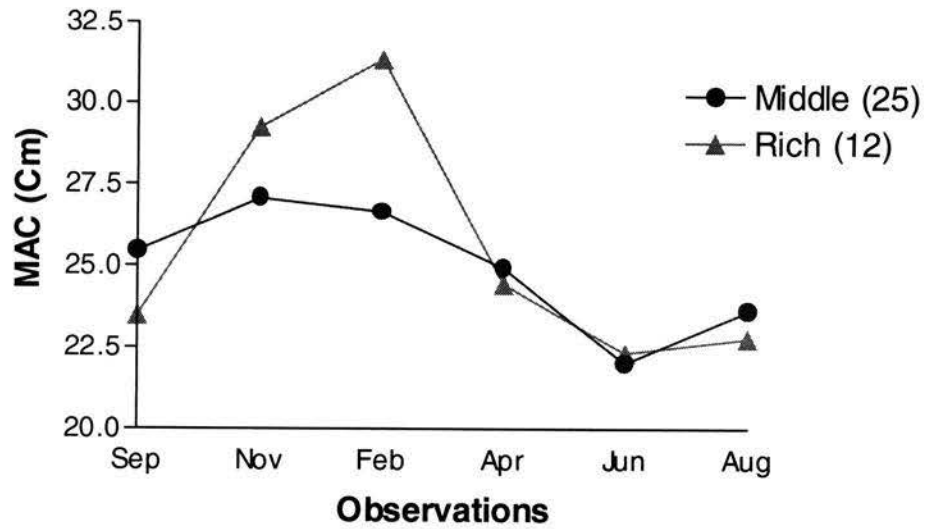
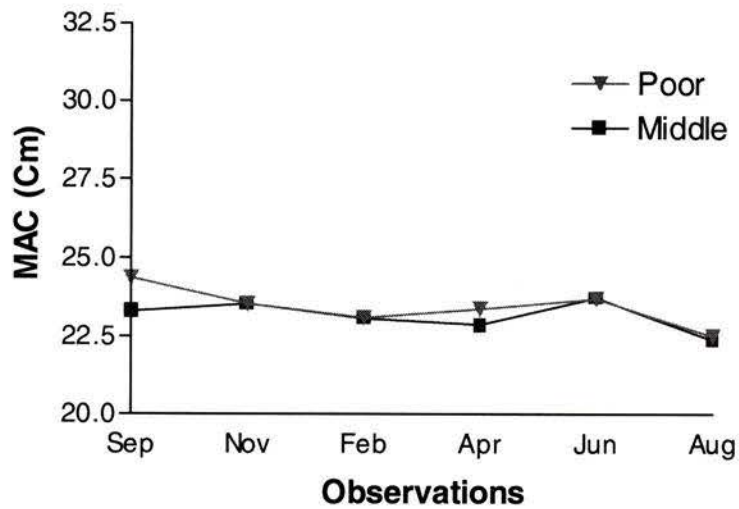


Figure 6-6
Mean MAC by Economic Status
in Songa in 1994-1995



These results do not provide any support for hypothesis 7 b), which predicts larger intra-community anthropometric differences in Songa than in Lewogoso. Rather, it was Lewogoso that showed significant interaction effects on MAC. Despite the milk sharing behaviours across economic strata in Lewogoso, seasonal effects on mothers' lean body mass were experienced differently depending upon their economic status.

6-4 Morbidity by Economic Status

Tables 6-9 to 6-12 summarize RM-MANOVA on morbidity by economic status. None of the results were statistically significant. This indicates that sedentarization did not translate into the differentiation of their morbidity episodes. Thus hypothesis 7c) was not supported.

Table 6-9
Summary Results for Repeated Measures Analysis of Variance: Tests of Hypotheses for Between-Subjects (Between-Economic Strata) Effects for Morbidity in Lewosogo (without poor stratum)

Morbidity	Sources	DF	Type III SS	Mean Square	F Value	Pr > F
Diarrhea	Econ	1	1.5762	1.5762	1.4	0.2441
	Error	35	39.3066	1.1230		
Fever	Econ	1	23.5360	23.5360	0.41	0.5278
	Error	35	2025.3377	57.8667		
Cold	Econ	1	0.8221	0.8221	0.03	0.8704
	Error	35	1064.6733	30.4192		

Table 6-10
Summary Results for Repeated Measures Analysis of Variance: Tests of Hypotheses for Between-Subjects (Between-Economic Strata) Effects for Morbidity in Songa

Morbidity	Sources	DF	Type III SS	Mean Square	F Value	Pr > F
Diarrhea	Econ	1	9.0963	9.0963	1.65	0.2069
	Error	36	198.1887	5.5052		
Fever	Econ	1	6.9959	6.9959	0.31	0.5804
	Error	36	809.1794	22.4772		
Cold	Econ	1	24.8508	24.850	1.18	0.2841
	Error	36	756.5394	21.0149		

Table 6-11
Summary Results for General Linear Models Procedure
Repeated Measures Analysis of Variance for Morbidity in Lewogoso
(without the poor stratum)

Repeated Measures Level Information

Dependent Variables: Diarrhea1 Diarrhea2 Diarrhea3 Diarrhea4 Diarrhea5 Diarrhea6
 Fever 1 Fever 2 Fever 3 Fever 4 Fever 5 Fever 6
 Cold1 Cold2 Cold3 Cold4 Cold5 Cold6
 Level of TIME: 1 2 3 4 5 6

Manova Test Criteria and Exact F Statistics for the Hypothesis of no TIME*ECON Effect
 H= Type III SS&CP Matrix for TIME*ECON, E= Error SS&CP Matrix

Anthropometry	Hypothesis Tested	Value	F	Num. DF	Den DF	Pr > F
Diarrhea	Time*Econ	0.9482	0.9275	2	34	0.4053
Fever	Time*Econ	0.8845	0.8096	5	31	0.5518
Cold	Time*Econ	0.8237	1.3270	5	31	0.2787

S=1 M=0 N=16 Statistic=Wilks' Lambda

Table 6-12
Summary Results for General Linear Models Procedure
Repeated Measures Analysis of Variance for Morbidity in Songa

Repeated Measures Level Information

Dependent Variables: Diarrhea1 Diarrhea2 Diarrhea3 Diarrhea4 Diarrhea5 Diarrhea6
 Fever 1 Fever 2 Fever 3 Fever 4 Fever 5 Fever 6
 Cold1 Cold2 Cold3 Cold4 Cold5 Cold6
 Level of TIME: 1 2 3 4 5 6

Manova Test Criteria and Exact F Statistics for the Hypothesis of no TIME*ECON Effect
 H= Type III SS&CP Matrix for TIME*ECON, E= Error SS&CP Matrix

Anthropometry	Hypothesis Tested	Value	F	Num. DF	Den DF	Pr > F
Diarrhea	Time*Econ	0.9140	0.6020	5	32	0.6987
Fever	Time*Econ	0.8569	1.0682	5	32	0.3962
Cold	Time*Econ	0.8737	0.9251	5	32	0.4776

S=1 M=1.5 N=15 Statistic=Wilks' Lambda

Summary

In short, sedentism increased the intra-community differences in dietary intake of beans and greens, attributed to economic strata. This might be a manifestation of the economic disparity, in which wealthier mothers had access to larger quantity of these foods, grown in larger and/or more productive garden plots or fields. As well, their higher integration into the town market (Fratkin and Smith 1995:450) might have allowed them to earn cash and in turn to purchase a greater variety of foods than others who had limited access to productive resources. The implications of such differentiation, particularly of bean consumption, are considered noteworthy due to its potential ramification for poor mothers' protein nourishment. However, neither anthropometric values nor morbidity episodes indicated apparent disadvantages of poor mothers in terms of their nutritional or health statuses.

Chapter 7

Summary and Discussion

This chapter first summarizes the results in the specific context of the seven hypotheses put forward at the beginning of the thesis. The chapter then puts these results in a wider context and considers their implications in an attempt to understand the consequences of sedentarization on maternal diet and health. The chapter then concludes with some recommendations for community policy directions as well as for further research.

7.1 Summary of Results

Hypothesis 1) In both communities, seasonal fluctuations in diet will be reflected in seasonal changes in maternal anthropometric and morbidity patterns.

The hypothesis presented was a heuristic device to explore the associations between seasonal patterns of diet and the nutrition and health of mothers in each community. This hypothesis was supported with regard to anthropometric patterns. For both communities, seasonal fluctuations in diet were reflected in seasonal changes in maternal mid-upper arm circumference (MAC) and triceps skinfold thickness (TSF) values. However, weight values did not show any apparent associations with dietary seasonality. For morbidity patterns the hypothesis was supported only for Lewogoso. Episodes of diarrhea and colds in Lewogoso were negatively correlated with seasonal fluctuations in diet, specifically with peak times of milk scarcity. Fevers in Lewogoso did not correlate with dietary seasonality but rather positively correlated with the rainfall peaks. In contrast, morbidity in Songa reflected neither dietary nor rainfall patterns,

regardless of the types of illness.

Hypothesis 2) Sedentary Songa will feature lower degrees of seasonal fluctuations in dietary intake, anthropometric values and morbidity episodes, relative to those of Lewogoso.

This hypothesis predicted that irrigation agricultural settlement would improve the availability of resources (through year-round access to water, stored food, and medical services) for mothers so that their diet and health would be less directly affected by the vagary of seasonal environments. Results supported this hypothesis with specific regard to dietary intake. Seasonal stress, measured by the degrees of fluctuations both in respective staple food and in dietary variety, clearly declined in sedentary Songa.

As for the anthropometric values, the hypothesis was supported only with respect to MAC values. The degree of seasonal fluctuation in MAC values was reduced in Songa relative to that for nomadic Lewogoso. In terms of TSF and weight Songa did not show any reduction in their degrees of fluctuations.

Morbidity patterns, however, provided no support for the hypothesis. None of the three types of illnesses – diarrhea, colds, and fevers – showed significant reduction in their degrees of seasonal fluctuations. On the contrary, prevalence of fever in sedentary Songa *increased* its seasonal fluctuations relative to that for Lewogoso.

Hypothesis 3) Songa will feature reduced protein intake relative to Lewogoso, as measured by milk and bean intake.

This hypothesis was based upon the assumption that a more market-oriented agricultural community would have less access to protein-rich food items. Dietary data supported this hypothesis. The quantity of milk consumed in Songa was significantly

reduced relative to that in Lewogoso all year round. However, Songa's bean consumption was higher and more constant, compensating for the reduction of dietary protein from milk sources. On balance the reduction in milk consumption appears to outweigh the increase in bean intake.

Hypothesis 4) Songa's mean MAC values will be lower than those of Lewogoso.

This hypothesis was based upon an assumption that prolonged reduction of dietary protein intake would lead to the reduction of body protein stores, crudely estimated by MAC, since dietary protein provides for structural materials for muscles and bones. The hypothesis was supported, but the scope of reduction in MAC was seasonal rather than permanent (or year-round), reflected in the "loss" of positive seasonal variation. During the four-month period immediately following the first rainy season when Lewogoso mothers' mean MAC values skyrocketed, Songa mothers' MAC values remained low and stable. Consequently, this loss of positive seasonal variation made Songa mothers' MAC values significantly lower than those of their nomadic counterparts.

Hypothesis 5) Lactating sedentarized mothers will be more vulnerable to protein depletion than lactating nomadic mothers, as measured by anthropometry.

This hypothesis predicted that reduced milk protein in agricultural community would negatively affect lactating mothers, a vulnerable group to low-protein diet, again crudely estimated by MAC values. The data did not particularly support this hypothesis. No significant anthropometric differences were observed when lactating mothers were compared between communities.

Hypothesis 6) Independent of community membership, lactating mothers will be more vulnerable to protein depletion than non-lactating mothers in the same community, as measured by anthropometry.

While similar to the previous hypothesis, this hypothesis predicted that the effects of elevated protein requirement for lactation would be visible in the comparison of MAC values between subgroups of lactating and non-lactating mothers within each community. Contrary to the prediction, this hypothesis was not supported; in neither community did MAC values provide evidence specifically for *protein* depletion of lactating mothers.

Surprisingly, however, the analysis revealed unexpected patterns of nutritional status. In Lewogoso, lactating mothers recorded *higher* fat reserves than did their non-lactating cohorts despite their supposedly elevated protein and energy requirements. Consequently, nomadic lactating mothers were effectively “sheltered” from caloric debts supposedly associated with lactation. In contrast, in Songa lactating mothers weighed significantly less than their non-lactating cohorts. Sedentary lactating mothers therefore were showing signs of nutritional debts, although such debts did not appear specifically as depletion of body protein stores. In any event, sedentary lactating mothers were not sheltered from the increased nutrient requirements for lactation. This absence of the “nutritional shelter” might be an adverse consequence of sedentarization.

Hypothesis 7) Sedentism will increase intra-community differences in dietary intake, anthropometric values, and morbidity episodes attributed to economic strata.

This hypothesis was based upon the notion that settlement would facilitate economic differentiation of the community that in turn would affect various aspects of

maternal dietary and nutritional/health statuses, depending upon their economic statuses. The hypothesis was supported with regard to dietary intake. In Songa, the intake amounts of two food items – beans and greens – were significantly differentiated by mothers' economic status. These disparities, particularly with respect to beans, conformed to the worldwide pattern of differential access to protein-rich food attributable to wealth statuses, as discussed earlier (Ch.3). In terms of anthropometric values as well as morbidity episodes, mothers in Songa did not show any significant intra-community disparities attributed to economic strata. Thus, while sedentism increased the magnitude of intra-community dietary differences attributable to economic status, such disparity did not directly translate into significant differences in either anthropometric values or morbidity episodes of mothers.

Economic analysis also produced insightful results for Lewogoso. The analysis of dietary intake revealed that two economic strata featured significantly divergent seasonal patterns in their starch intake. Since the difference between strata was expressed as differing seasonal patterns and not as systematic differentiation in quantity, in which one stratum is better or worse than the other, this was not considered as a counter-example to the hypothesis. The results were noteworthy, nevertheless, because it was a clear departure from the notion of egalitarian pastoral sharing.

7.2 Discussion

7.2.1 Dietary and Health Consequences of Agricultural Sedentism

This section considers the above results with this study's two-fold purpose in mind. The first purpose was to understand the consequences of sedentarization on maternal

diet and health, and how they may intersect with seasonality and economic status. The second purpose of this study was to contribute to the *Rendille Sedentarization Project*, the three-year parent project.

The most notable consequences of sedentism was the differences between dietary practices of nomadic Lewogoso and sedentary Songa, each of which encompassed the distinctive staple food as well as the distinct seasonal pattern of consumption (Fujita 2000). Diet in Lewogoso was predominantly milk based, with a high seasonal volatility in its intake. Songa residents, on the other hand, consumed predominantly starch, with little seasonal fluctuation in its intake. These patterns imply that agricultural sedentarization has simultaneously affected at least two different aspects of the diet. On the one hand, nutritional values have shifted from a high-protein and low-calorie milk-based diet to a low-protein and high-calorie starch-based diet. On the other hand, seasonal stress has diminished.

The question was then how these distinct dietary patterns might have differentially affected mothers' nutritional health. Analysis revealed that the reduction of dietary protein, the increase in dietary energy, and the alleviation of seasonal dietary stress in Songa affected sedentary mothers' body compositions such that their body fat and protein stores fluctuated distinctly from each other. Specifically, sedentarization reduced the degree of seasonal volatility in protein stores, whereas that for fat reserve remained relatively stable.

Morbidity patterns of Songa reflected neither the dietary seasonality nor the seasonal patterns of rainfall. Yet the degree of seasonal fluctuation of morbidity in Songa were either equivalent to (for diarrhea and colds) or higher than (for fevers) in Lewogoso,

suggesting that the health of sedentary mothers were likely to be affected by factors other than their dietary stresses or resource fluctuations associated with rainfall patterns. Such factors may include the increased energy expenditure and/or the increased presence of pathogenic agents, both of which may play more important roles in determining the health of mothers in Songa. For instance, increased workload for agricultural tasks or for marketing efforts may negatively affect mothers' energy balance or immunity level. As well, insults from disease vectors, such as mosquitoes, the carrier of malarial agents, unique to an irrigation community with permanent standing water might be a more important factor for the prevalence of fevers than dietary or resource stresses. This may also partially explain the year-round prevalence of diarrhea in Songa as opposed to its season-specific prevalence in Lewogoso.

The consequences of low-protein and high-carbohydrate diet were also explored to see if dietary change would vary with mothers' lactation status. Lactating mothers with high requirements for dietary protein were suspected to feature negative consequence, evidenced by a reduction in their body protein stores. However, lactating mothers did not show such signs, roughly estimated by MAC, regardless of their community memberships. Neither were sedentary lactating mothers more disadvantaged than nomadic lactating mothers in terms of protein stores.

Yet a closer analysis of within community comparison revealed that lactating mothers in nomadic Lewogoso had unexpectedly higher energy reserves than non-lactating mothers in the same community. By contrast, lactating mothers in Songa showed greater nutritional stress relative to their non-lactating cohorts, as expected from the elevated nutrient requirements for lactation. Whatever the mechanism was, pastoral mothers were effectively sheltered from extra nutritional demands required to sustain

lactation as well as to maintain their own health. This “loss” of nutritional shelter is one defining contrast between nomadic and sedentary lactating mothers, and is considered a potentially negative consequence of sedentarization for lactating mothers.

This unusual phenomenon of “nutritional shelter” might be a mere anecdote. However, this might constitute a beneficial effect of high-protein/low-calorie pastoral diet with a potential adaptive value for human reproduction in a highly seasonal environment. How high-protein/low-calorie diets may influence human biology and reproduction is not yet fully understood (Galvin and Little 1999: 144-145). This pastoralists’ “nutritional shelter” deserves further research not only for understanding the influence of a high-protein/low-calorie diet on human reproduction and health, but also for understanding the ramification of a departure from such diets.

Analyses by economic status revealed disparities within Songa, in which the poor had significantly reduced servings of beans and greens. The notion that socioeconomic status may determine whether or not one will benefit or suffer from an economic transition (Popkins et al. 1993; Shell-Duncan 2000; Shell-Duncan et al. 2001) was true for dietary status of Ariaal and Rendille mothers in Songa. Given the low-protein quality of their diet, the disparity in bean intake, a major source of dietary protein for Songans, would potentially lead to disparities in health status of mothers attributed to their economic status.

In this study of a normal year with a bimodal rainfall pattern, however, these dietary disadvantages of poor mothers were not directly translated into their nutritional status, as measured by anthropometry and morbidity.

7.2.2 Why results were different from those for children.

As discussed in the above section, some changes in maternal nutritional and

health statuses (the change in their body composition and morbidity patterns, as well as the loss of nutritional shelter for lactation) were striking consequences of sedentism on mothers. It is, however, important to note that the results for anthropometric and morbidity values in general were not as strong as those previously found for children in the *Rendille Sedentarization Project* by Nathan et al. (1996), Fratkin et al. (1999), and Roth et al. (n.d.). In these studies, settled Ariaal and Rendille children were found with nutritional debts much more clearly visible all year around. Some points may explain why results were different from those for children.

Adult bodies may be simply less sensitive to dietary changes. Children require extra nutrients for growth and development. While there is no question that mothers too have greater needs for nutrients if they are pregnant or lactating, the consequences of sedentarization and associated dietary changes may be less dramatically expressed in their anthropometry and morbidity values. The data used in this study were collected around the 20th year since Songa's establishment. Subjects of this study thus are likely to consist of the admixture of women who spent their childhood in a nomadic community and later migrated to Songa and those who spent most of their lifetime in Songa. Although I did not have access to the information on such backgrounds of samples it is likely that many have settled after their growth and development periods so that they had already achieved physical characteristics unique to pastoral nomads prior to their relocation to Songa. This might be a confounding factor for the above mentioned.

An additional reason may be in improvement of mothers' energy intake. Since this study focused predominantly on dietary protein, little systematic attention was given to dietary energy. It is clear, however, that sedentism improved maternal access to dietary energy despite the reduction in their intake of dietary protein, at least in a normal year. The

diet in Songa, despite its reduction in protein content, had some positive features such as high carbohydrates content, increased energy values, and improvement in fiber, vitamins, and mineral contents. A diet with high carbohydrate content is known to contribute to an improvement in endurance of a person through an increased glycogen stores (Whitney et al. 1990: 401). As well, “when carbohydrates yield energy, they spare proteins from being used for energy so that proteins can do the jobs they are uniquely suited for” (Whitney et al. 1990: 72). Improved fiber, vitamins, and mineral contents would potentially enhance health through their conditioning properties. For example, vitamins and minerals assist in releasing energy from fuels and in transporting oxygen within our body (Whitney et al. 1990: 410).

Since the caloric deficit is a severe matter of fact in nomadic communities, the high energy-yielding carbohydrate-based diet would be a welcome change. Agricultural sedentism therefore has the potential to provide a number of beneficial effects on mothers’ dietary and nutritional status provided that they have sufficient access to dietary protein.

7.2.3 Seasonal Perspective

This study demonstrated the importance of the seasonal perspective in the study of sedentarization. The strength of this study lies in its longitudinal study design, in which data reflected the vital resource fluctuation in a non-drought year with the normal seasonality for both nomads and agriculturalists. This enabled understanding of the seasonal dimensions of dietary and nutritional health consequences on these mothers, who live in a highly seasonal environment. This first allowed an examination of temporal patterns, correlation, and associations among nomadic mothers’ dietary, anthropometric and morbidity patterns, all of which were closely related to seasonal fluctuation of rainfall

and resource availability.

Second, the seasonal perspective was also valid for understanding diet and health of those who have settled in such a way that a cross-sectional study would not be able to address. Morbidity episodes of Songa mothers, for example, revealed the seasonal pattern that is clearly distinct from not only that of nomads, but also from dietary patterns of Songans themselves, providing a strong indication of new factors at play affecting mothers' health status.

Finally, when seasonal and economic perspectives were paired, the results further revealed that seemingly egalitarian nomadic mothers showed dietary variation in starch intake attributed to economic status. While milk-sharing customs do exist among mothers, energy-yielding starch was not readily shared among them. One reason for this may be due to the starch supply originating in relief rations. Such sources would supply food based upon individuals' needs. Poor mothers may have benefited more from relief maize meal than those who were better off. Yet those who were better off might have had enough livestock that they could exchange with maize or maize meal. Thus these two sub-groups may have consumed starch from different sources. The timing of these two sources would plausibly vary. Inferring from nomadic mothers' mobility, which prohibits them from possessing large store of food, such divergence of sources would further result in notable variations in intake amount and timing attributable to economic strata.

7.2.4 A Policy Recommendation

In order to prevent potentially negative nutritional and health consequences of the protein reduction associated with agricultural sedentism, particularly on poorer families, more equitable distribution of protein-rich food items would be a meaningful goal to strive

for.

One way to alleviate the protein scarcity in Songa's diet would be to increase their animal holding in order to obtain more milk or continue and strengthen their existing ties to the pastoral sectors of the society in order to secure better access to milk. However neither of these suggestions is realistic for Songa. The former is unrealistic because there is a limitation to the number of animals people can keep in the community because of the potential destruction to their farms. The latter solution of increasing ties to the pastoral sector is a possibility, but not likely to lead to an increase of daily supply of milk given the long distance between camps and the settlement. As well, this solution presumes the continuation of the Ariaal and Rendille pastoral sector's cultural and socio-economic integrity, which is currently under increasing threat.

A more realistic solution may be available through improvement of plant protein sources. Maize protein may be more efficiently processed through an adoption of a new cooking method with alkali. Yet another and perhaps better option would be to improve the production and distribution of beans. Through the protein complementarity, beans will serve as a good alternative protein source that Songans might have a better control over to incorporate in their regular diet. This requires an increased production of beans for domestic use rather than for market sale, so that local dish such as *githeri*, made of maize and beans, be more readily available.

7.2.5 Further Research

In this study I used the data from a normal year with a bimodal rainfall pattern. In drought years, both nomadic and sedentary communities would show dietary statuses that are different from those in normal years. Using the findings of this study as baseline data, a

new set of questions may be asked. Would nomadic mothers still have heightened seasonality in their dietary intake, anthropometric, and/or morbidity patterns as they did in a normal year? Would sedentary mothers still have access to dietary energy and proteins as they did in a normal year? Would the “nutritional shelter” for lactating mothers still appear intact in drought years? How would the lack of rain affect economic disparity in dietary, anthropometric, or morbidity patterns? These are some questions that should be examined in future research in order to fully understand the health consequences of agricultural sedentism on Ariaal and Rendille mothers.

In a few years, Songa will record the 30th year since its establishment. A larger segment of mothers will have been born and raised as children of settled former pastoralists in Songa. The consequences of agricultural sedentism would be manifested more clearly if a future study explores the health of and the reproductive success of these second generation mothers. More than ever before, systematic inquiries into the complex consequences of sedentarization are anticipated in the years to come.

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