UNIVERSITY OF CALGARY

Seasonal Variation in the Dietary Adequacy of the Rupununi Makushi of Guyana, South America

by

Shawna Gwendolyn Ardley

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Abstract

The present study describes how seasonal variation influences the nutritional intake of the Makushi Amerindians (sample population 73 males and 124 females in child, adolescent, and adult age groups) of the Rupununi region Guyana, South America. Previous research in nutritional anthropology has documented that seasonal patterns of rainfall and temperature affect diet in indigenous populations. Data was collected via two methods: 24-hour dietary recalls and semi-structured interviews. Overall the Makushi exhibit little significant seasonal variation in energy, fat, and protein intakes, although there is functionally significant seasonal variation in vitamin A and food variety. These findings appear to be related to ecological factors, such as the calendar of subsistence activities, cultural methods of food storage and processing, and the aseasonal nature of manioc, the staple crop. Considering village-based cohorts, there is a trend among female children for higher wet season intakes of energy and protein, and among female adults for higher wet season intakes of vitamin A. The cause of these differences may be associated with distinctive sex-related activity patterns, differential household distribution of food resources, or cultural and symbolic beliefs. There was no general tendency found to assert that age and sex groups were affected in different manners by seasonal food supplies. Understanding the impact of seasonality on the diet of the Makushi has important implications for studies of human adaptation and the evolution of human biology and culture in lowland South America.

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List of Symbols, Abbreviations and Nomenclature

ANOVA	Analysis of variance
BMI	Body mass index
CNP	Cyanogenic potential (of manioc)
EAR	Estimated Average Requirement
FAO	Food and Agriculture Organization
IU	International Units
MRU	Makushi Research Unit
NCHS	National Centre of Health Statistics
NHANES	National Health and Nutritional Examination Surveys
NRDDB	North Rupununi District Development Board
RDI	Recommended Daily Intake
SD	Standard deviation
UNU	United Nations University
WHO	World Health Organization

CHAPTER ONE: INTRODUCTION

1.1 Background

Studies of rural, indigenous populations have documented a strong relationship between seasonal fluctuations of temperature and rainfall and the amount of food resources consumed (Messer, 1989; Beall et al., 1996; Omori and Greksa, 2002). Nutritional intake and adequacy in traditional societies may be largely dependent on seasonal factors and the temporal variability in the type and amount of food resources (Kormondy and Brown, 1998). Johnston (1989:11) concurs, noting "...the ability of the diet to satisfy the nutritional requirements of a population is dependent not only upon features such as habitat, technology, and biomass, but also upon the effects of fluctuations in the environment upon food availability." Consequently, in regions where the there are marked seasons, these societies must adapt their subsistence strategies accordingly. The goal of this research is to understand the impact of seasonality on the diet of the Makushi Amerindians of Guyana.

Human societies are responsive to the seasonality that defines their ecosystems. Seasonality is the "regular, recurring, intra-annual fluctuation" of the climate (Huss-Ashmore, 1988:5). Interactions between populations and environmental seasonality are dynamic, which produce methodological and interpretative problems for scientists studying health and diet (Johnston, 1989) and traditional subsistence systems.

Traditional subsistence strategies are defined here as a historically influenced pattern of activities and practises that manage the surrounding environment in a manner to continually provide energy and other dietary nutrients. One such strategy among this study population is swidden cultivation that involves clearing and burning a forested area (Forte, 1996[1]). Farm products are cultivated and harvested for several years after which the land is left to reforest for 15-30 years. Swidden cultivation promotes soil fertility, permits the accumulation of nutrients, and reduces the appearance of pests (Dufour, 1983). Fishing, hunting, and collecting floral and faunal resources is an integral part of traditional subsistence strategies, and supply dietary sources of fat, carbohydrates, and protein (Dufour, 1983; Forte, 1996). While researchers have discussed seasonality in studies the indigenous diets (e.g. Leonard and Thomas, 1989; Beall and Goldstein, 1993; Omori and Greksa, 2002), our current understanding of these groups can be enhanced by taking a diachronic perspective to investigate how traditional subsistence strategies, food resource availability, individual perceptions of seasons, and nutritional intake vary in regions with marked seasonality.

Toward this end, this research explores the impact of seasonality on the diet of the Makushi Amerindians of Guyana. The Makushi inhabit a region that is subject to seasonal fluctuations in temperature and precipitation. In particular, this research attempts to elucidate how this seasonality might impact the subsistence practises of the Makushi.

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[1] The reference refers to an edited book, *Makusipe Komanto Iseru: Sustaining Makushi Way of Life*, which includes anecdotal accounts and information provided by Makushi women who are collectively known as the Makushi Research Unit. This book, written about and by the Makushi, is integral to this study as it provides information on subsistence strategies, species indigenous to the Rupununi, and the Makushi way of life. Full reference provided.

1.2 Research Goals

The present research addresses and evaluates the impact of seasonal variation on the nutritional intake of the Makushi Indians of the northern Rupununi region of Guyana, South America. The following two hypotheses will be tested:

> Hypothesis 1: Seasonality, defined by the wet season and the dry season, affects patterns of nutritional intake among the Makushi.
>
> Hypothesis 2: The Makushi people of different age and sex groups will be affected in different manners by dietary seasonality.

1.3 Significance

There are three potential benefits that may grow out of a better understanding of the effects of seasonality on nutritional adequacy. First, this knowledge enhances our understanding of human adaptation to the lowland tropics. Second, investigating dietary seasonality may help us to comprehend the physical growth and development patterns found among indigenous peoples of South America's lowland tropics (e.g. Stinson, 1990; Dufour, 1992). These two points, in turn, have the potential to enhance our understanding of the evolution of human biology and culture among horticulturists in regions with marked seasonality, which may allow for a better comprehension of human populations with similar cultural and biological foundations. Third, a possible practical application of this research is that it may refine our knowledge of the relationship between seasonality and diet and lead to more efficient allocation of resources for regional aid programs.

In addition, this research provides a comparison of two different methods of evaluating nutritional intake: 24-hour dietary recalls conducted with individuals and group interviews concerning dietary seasonality. Comparing the results of these two methods will test the reliability and validity of each interview strategy. Finally, this research will provide comparative literature for future studies of seasonality and diet.

1.4 Thesis Outline

The following chapter provides a review of the literature concerning seasonality and nutrition. Case studies will illustrate how different populations alter their subsistence strategies and patterns of energy expenditure to cope with seasonality. Chapter three will present the subjects and setting of this research, including a summary of the history, ecology, and resource management and subsistence strategies of the Makushi. Chapter four will detail the methods implemented to collect data, such as 24-hour dietary recalls and semi-structured interviews. The results and discussion, Chapter five and six, respectively, will present the results and discussion, and will be followed by the conclusion.

CHAPTER TWO: SEASONALITY AND NUTRITIONAL ADEQUACY

2.1 Background

This research aims to understand the relationship between seasonality and the diet of the Makushi Amerindians of Guyana. Seasonal variability may influence the nutritional adequacy of a population by altering resource availability and/or by altering the manner of resource acquisition. For example, horticulturists generally plant on seasonally directed schedules (Forte, 1996; Lizot, 1993; Dufour, 1983).

Seasonal variability also influences physical activity patterns, which are largely determined by the manner of obtaining food resources. Changes in physical activity patterns may affect nutritional adequacy. Level of physical activity, age, sex, and body weight determine energy intake requirements as outlined by the Food and Agriculture Organization and the World Health Organization of the United Nations (FAO/WHO) (1973). For example, among equatorial populations in South America, foraging groups tend to focus on gathering activities in the dry season, as travel is easier and less energy is expended during this season (Moran, 1982), even though wild plants are available at different times throughout the year.

The following section will present case studies illustrating how seasonality influences subsistence strategies among indigenous populations. Section 2.1.2 will present examples of the potential for seasonality to vary energy expenditure and nutritional requirements.

2.2 Seasonal Variation in Subsistence Strategies

The interaction between human populations and their ecosystems is dynamic. One way to evaluate this interaction is to consider the subsistence strategies of indigenous populations which have, more or less, maintained traditional practices. Case studies of peoples from low to high altitudes, practising traditional subsistence strategies document dietary seasonality. For example, among both horticulturists, such as the Highland Pwo and Sgaw Karen of Thailand (Omori and Greksa, 2002), and hunter-gatherers, such as the Netsilik Inuit of Nunavut (Balicki, 1970) and the žu/õasi San of the northwestern Kalahari desert (Truswell and Hansen, 1976; Wilmsen, 1978), food production varies with seasonal changes.

Several case studies are provided below to reveal the particulars of this variation. The San of the Kalahari have adapted to a cyclical variation in food supply in which nuts, important sources of protein, fat, and calories, are available from April through December, and leguminous beans are available January through May (Wilmsen, 1978). Meat availability peaks in June and milk provides a substantial dietary supplement from December through April (Wilmsen, 1978). The Karimojong of East Africa farm during the months prior to the rainy season, which occurs in April through September. (Dyson-Hudson and Dyson-Hudson, 1969). They subsequently dry and store farm products such as millet, corn, pumpkin, and peanuts during the early dry season, when the Karimojong hunt and gather to supplement their diminishing farmed food resources (Kormondy and Brown, 1998).

Further examples of seasonal variation in subsistence strategies are found among Bangladeshi populations located on low-lying delta land who tend to experience food shortages during September and October, during the monsoon floods, and are forced to await the harvest of deep-water rice crops (Walsh, 1981). Among Tibetan Nomads, the seasonal diet of primarily boiled mutton or yak meat in the winter, and *tsamba* (roasted barley flour) plus dairy products in the summer results from differences in summer and winter subsistence activities (Beall and Goldstein, 1993; Beall et al., 1996).

The Igloolik Inuit from the northwest coast Baffin Island's Melville Peninsula have an annual cycle of subsistence activities that modifies the population distribution (Little and Morren, 1976). During the spring these Inuit disperse into scattered camps to better hunt seals and terrestrial mammals, and by summer they form concentrated inland settlements to hunt caribou. During the fall and winter seasons the Inuit concentrate in protected bays along the shoreline and subsist on stored food and hunt seal and birds (Godin, 1972). The Ache hunter-gatherers of Eastern Paraguay consume more high energy foods such as honey, fruit, and insect products during the warm or "fat" season (November through February) than during the "cold" season (May through August) (Hill et al., 1984).

2.2.1 Seasonal Variation in Subsistence Strategies of Lowland Tropic Populations

Numerous indigenous populations of South America's lowland tropical regions have seasonally influenced subsistence strategies. In addition to hunting and farming, they collect wild plant foods to augment their diets (Dufour and Wilson, 1994). This activity requires knowledge of the seasonally determined fruiting schedules of the plant species utilised (Dufour and Wilson, 1994).

2.2.1.1 Yanomami of Venezuela

The Yanomami inhabit the interior mountainous, rainforest region of southern Venezuela. Plantains and bananas are the dietary staples of the Yanomami, game is the main source of protein, and wild plant foods are heavily relied upon (Lizot 1993). The Yanomami utilise about forty species of wild plants, the fruiting schedule of which is chiefly dependent on seasonal cycles, as is the availability of fish, game, and insects (Lizot, 1993). For example, gathering is frequent during two fruiting seasons, one during the wet season from May to August and the second during the dry season from December to February (Lizot, 1993). As such, the Yanomami diet is highly seasonal. The average energy and protein intake per day is 1794 kcal and 67.55 g, respectively (Lizot, 1993).

The Yanomami are recorded as the shortest people inhabiting the Amazon (Dufour, 1992), and Holmes (1985) noted that, the Yanomami had poor nutritional status and that most children between the ages of one and 12 were thin and would be considered severely undernourished. These observations would suggest that the Yanomami do not obtain sufficient food supplies and their short stature and the appearances of wasting among children could be symptoms of chronic and acute nutritional deficiencies. Whether or not dietary seasonality plays a role in this cannot be determined without further research.

2.2.1.2 Hiwi of Venezuela

The Hiwi hunter-gatherers of southwestern Venezuela also experience seasonal variation in subsistence strategies. This population is comprised of a central settlement with scattered bush camps and inhabits the neotropical savannahs (*llanos*) of the Orinoco River basin, which are influenced by seasonal patterns (Hurtado and Hill, 1987; 1990). The *llanos* have a unimodal rainfall seasonality, whereby 90% of annual precipitation falls between the May and November, followed by a severe dry period between January and March. The Hiwi diet is comprised primarily of fish and game, which varies by the season. Wild plant foods including root vegetables, fruits and other vegetables are also consumed and provide 68%, 19%, and 8% of the daily energy intake, respectively (Hurtado and Hill, 1987, 1990). Agricultural products and store-bought foods contribute an additional 4% to daily energy intake. Energy derived from root vegetables was significantly higher in the late wet season when energy intake peaked (2756 ± 473 kcal; September through November), while energy derived from other wild plant foods and store-bought foods peaked in the early wet season when energy intake was lowest (1350 ± 220 kcal; May through August).

2.2.1.3 Curripacos of Venezuela

The Curripacos, studied by Holmes (1985), live in San Carlos de Rio Negro, Venezuela, a town of 600 people, and three neighbouring villages. The traditional diet of the Curripacos is based on fish- or meat-based soups with manioc starch or *farine* added, the principal beverage is *yucuta*, and the main source of dietary protein is fish. Holmes (1985) noted several signs of undernutrition, including sparse and/or dispigmented hair among 25-50% of children, short stature throughout age cohorts, and 80% of school-aged children were below the 10^{th} percentile of WA of the Venezuelan standard.

2.2.1.4 Tukanoans of Colombia

The Tukanoans of Colombia experience minimal seasonal changes in dietary intake due to the seasonal availability of food resources (Dufour, 1992). While seasonal patterns are much less marked in the northwestern Amazon compared to the Rupununi region of Guyana, fishing is a dominant dry season activity and wild food collection occurs predominantly in the wet season. *Manioc* is the staple crop (Dufour, 1992). The Tukanoans supplement the collection of wild food plants and cultivated crops in the diet by collecting and consuming insects (Dufour, 1987). Although the Tukanoans gather insects, such as ants and termites, throughout the year, collection rates peak in April and May, a period that coincides with the nuptial flights of ants and termites and the initiation of the young Tukanoan males who may only consume ant and termite soldiers. A second peak in collection rates occurs in September, also coinciding with the insect nuptial flights (Dufour, 1987).

Nutritional intake and energy expenditure for the Tukanoans is adequate, when evaluated against FAO/WHO (1973) reference standards. However, Dufour (1992) proposes that the high bulk, low energy density and poor nutritional quality of the Tukanoan diet may be contributing to stunting among young children (see Section 2.*). Observations of skeletal musculature showed adequate intake energy and protein, whereas low levels of subcutaneous fat and clinical signs of undernutrition reported by

Ortiz (1981; in Dufour, 1994) may indicate that the Tukanoans may have a diet continually lacking in several micronutrients.

2.2.1.5 Patamona of Guyana

The diet of the Patamona, a lowland South American indigenous group inhabiting the interior region of Guyana, is influenced by seasonality. The staple crop of the Patamona diet is manioc, with several other ground provisions, such as eddoe, dasheen, corn, yam, and plantain, providing important sources of carbohydrate (Dangour and Ismail, 1994). Manioc-derived products such as *farine*, *casareep*, *cassiri* (composed of grated, bitter manioc boiled with grated, purple potato), and *parakari* are consumed by the Patamona. Protein-rich legumes, such as *Vigna* spp., *Phaseolous* spp., and *Cajanus* spp., are seasonally available, reaching maturity in February and March, after the short wet season (November and December) and in September and October following the long wet season, which spans May through September. The Patamona rarely consume animal protein, with fish intake once every three or four weeks and game intake once a month or less, and green vegetables and fruits are not eaten frequently.

The paucity of animal protein and seasonal availability of green vegetables in the Patamona diet may render their diet deficient in minerals such as zinc, calcium, and iron and vitamins such as folate, which in turn may contribute to the growth faltering exhibited in these communities (Dangour and Ismail 1994). Likewise, Dangour (1997) reports that crop diversity and household quality, determined by evaluating household construction materials, household size, position of cooking area, and the presence of a pit latrine, are the most important factors influencing growth and development and determining nutritional status among the Patamona. He contends that increased crop diversity may provide greater dietary diversity, and improved hygienic and environmental conditions within the household may provide a better arena for optimal growth and development (Dangour, 1997).

In conclusion, these are but a few of a number of case studies that document seasonal variations in subsistence practises and diet.

2.3 Seasonal Variation in Nutritional Requirements

The seasonal variations in diet and subsistence strategies suggest that these groups may also experience seasonal variation in energy expenditure and, thus, nutritional requirements.

Several case studies are provided here to illustrate the potential for variation in energy expenditure and nutritional requirements. The Quechuans of the Andean community of Nuñoa, Peru, who subsist via both horticulture and pastoralism, realise that energy availability cannot support required activity levels of adults in the pre-harvest season (Leonard and Thomas, 1989). As such, the adults decrease activity levels and depend on children to carry out energy expensive household maintenance activities, such as herding animals, collecting fuel for cooking fires, and caring for infants (Leonard and Thomas, 1989). In the Sahel region of Upper-Volta (Burkina Faso, Africa), male farmers decrease energy output during the dry season, possibly due to the need to reconstitute their physical fitness after a long period of arduous labour during the wet season (Brun et al., 1981). During the wet season, female farmers in this region expended on average 500 kcal/day more than was expended during the dry season, causing a negative energy balance (Bleiberg et al., 1980). Tetens et al. (2003) report that in rural Bangladesh, seasonal fluctuations in energy intake differ in all age and sex groups studied. Among adults, chronic energy deficiency, as evidenced by a body mass index (kg/m^2) less than 18.5, was more prevalent in the postharvest season than in the preharvest season, despite greater energy intake during the postharvest season (Tetens et al., 2003). This suggests that the dietary intake of adults was not adequately adapted to seasonal changes in energy expenditure (Tetens et al., 2003). Among Gambian peasant agricultural workers with seasonally limited peak work periods, a pattern of post-harvest feasting was observed, which should lead to weight gain and improved nutritional status for the planting period when energy demands are greatest (Dugdale and Payne, 1986, 1987). Properly understanding nutrition and how to assess nutritional status helps to assist with interpretations of seasonal dietary adequacy.

2.4 Nutrition

Energy balance is a state achieved by a person when the energy consumed equals the energy expended (Whitney and Rolfes, 2002:241). The three components of energy balance are intake, expenditure, and storage (Huss-Ashmore, 1996). Thus, when energy intake exceeds energy expenditure energy is stored, often as fat, generating weight gain. When energy intake is less than the amount of energy expended, the reserves are utilised and depleted and, thus, the individual loses weight.

Nutritional adequacy is the result of a balance between supply of nutrition and the expenditure of the organism (McLaren, 1976), such that physiological homeostasis is maintained. A nutritional requirement is the lowest continuing intake of a nutrient that will maintain a specified criterion of adequacy (National Academy of Sciences (FNB), 2001; FAO/WHO, 2002; Whitney and Rolfes, 2002). Nutritional requirements can be met in a variety of ways through consuming macronutrients and micronutrients.

Table 2.1 1997-2001 Recommended daily allowances (RDA) of macronutrients by sex and age group. (Adapted from National Academy of Sciences, 2001)

Nutritional Component	RDA							Nutrient Metabolism	Calculation Factor
	Children (1-12)		Adolescents (13-19)		Adults (>=20)		Pregnant/Lactating		
	Male	Female	Male	Female	Male	Female			
Energy (kcal)	1900	1900	3000	2200	2300 - 2900	1900 - 2200	2400-2700		
Carbohydrate (g)	260	260	375	275	365	275	350	1. Provides energy 2. Effects satiety and gastric emptying 3. Controls blood glucose and insulin metabolism 4. Produces glucose from protein 5. Effects cholesterol and triglyceride metabolism 6. Converts glucose to fat (Whitney and Rolfes, 2002; FAO, 199	55% of total energy
Total Fat (g)	63.33	63.33	100	73.33	96.67	73.33	63-73	1. Insulate the body 2. Serve as a shock absorber for the vital internal organs 3. Provide an energy reserve when stored in fat tissue 4. Help the body use carbohydrates and protein efficiently (Whitney and Rolfes, 2002)	30% of total energy

Table 2.1 cont. 1997-2001 Recommended daily allowances (RDA) of macronutrients by sex and age group. (Adapted from National Academy of Sciences, 2001)

Nutritional Component	RDA							Nutrient Metabolism	Calculation Factor
	Children (1-12)		Adolescents (13-19)		Adults (>=20)		Pregnant/Lactating		
	Male	Female	Male	Female	Male	Female			
Protein (g)	26	26	59	44	61	48	70	Work: 1.As enzymes, or protein catalysts that facilitate chemical reactions 2. As hormones 3. As maintainers of the proper type and amount of fluid in each compartment of the body 4. As regulators of the acid-base balance in the body 5. As transporters of	15% of total energy

Macronutrients include carbohydrate, fat, and protein (Table 2.1). These three organic nutrients provide energy and raw materials for building bodily tissues and regulating its functions (FAO/WHO/UNU, 1985; Whitney and Rolfes, 2002). Micronutrients are inorganic and organic chemical structures in food used by the body to supply energy, structural materials, and regulators to assist growth, maintenance, and repair of bodily tissues (FAO/WHO, 2002; Whitney and Rolfes, 2002). Non-energy producing micronutrients include vitamins and minerals. The Recommended Daily Allowances (RDA) of vitamins and minerals are outlined in Table 2.2.

Common practises followed to meet nutritional requirements include consuming sufficient energy and essential nutrients to maintain health, and balancing the diet through moderation and variety (USDA, 2000). Consuming low amounts of animal products and a high diversity of grains, fruits, and vegetables is better than a restricted diet of low diversity (USDA, 2000; Whitney and Rolfes, 2002).

2.5 Nutritional Deficits Associated with Seasonality

If dietary adequacy changes with season, then it is important to examine how nutrition varies from season to season. Food resources become substantially reduced most frequently directly before the harvest period. In several regions, the pre-harvest period often coincides with an increased prevalence of inadequate nutrition and morbidity (Omori and Greksa, 2002; Leonard and Thomas, 1989). For example, among mothers and children of the Highland Pwo and Sgaw Karen of Thailand the percent of recommended daily intake (RDI) of calcium, iron, vitamin A, riboflavin, and thiamine were inadequate for the majority of the year. However, the percent of RDI for iron, vitamin A, thiamine, riboflavin, niacin, and ascorbic acid tended to decrease from postharvest to preharvest season and subsequently increase during the harvest (Omori and Greksa, 2002). The Sahelian zone of Chad is classified as a region where vitamin A deficiency is a significant health problem (WHO, 1985). Begin et al. (1992) report that 61% of households in the non-harvest season and 42% of households in the harvest season were below 60% of the safe level of vitamin A intake, which was set at 500μg RE(retinol equivalents)/day and 600μg RE/day for adult females and males, respectively. The large non-harvest season vitamin A deficit could be explained by a decrease in milk consumption (39% of households consuming milk in the non-harvest season compared to 60% of households consuming milk during the harvest season) (Begin et al., 1992).

In addition to measures of nutritional intake, physical growth status is an indicator commonly used to assess dietary adequacy and nutritional status.

Table 2.2 Recommended daily allowances (RDA) of selected vitamins and minerals (Adapted from National Academy of Sciences, 2001)

Nutritional Component	RDA							
	Children (1-12)		Adolescents (13-19)		Adults (>=20)		Pregnant	Lactating
Vitamins	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**		
Vitamin A (IU)	3000	3000	5000	4000	5000	4000	5000	5000
Vitamin C (mg)	25	25	75	65	90	75	85	120
Thiamin (mg)	0.6	0.6	1.2	1	1.2	1.1	1.4	1.4
Riboflavin (mg)	0.6	0.6	1.3	1	1.3	1.1	1.4	1.6
Niacin (mg)	8	8	16	14	16	14	18	17
Minerals								
Calcium (mg)[1]	800	800	1300	1300	1000	1000	1000	1000
Iron	10	10	11	15	8	18	27	9
Sodium (mg)[2]	500	500	500	500	500	500	500	
Potassium (mg)[2]	2000	2000	2000	2000	2000	2000	2000	
Phosphorus (mg)	500	500	1250	1250	700	700	700	700

[1]1997 Adequate Intake (AI)

[2]1989 FDA estimated minimum requirement

2.6 Assessing Nutritional Status

2.6.1 Measurements of Physical Growth

2.6.1.1 Why Measure Physical Growth?

There are a variety of ways in which nutritional status can be assessed. Knowledge of energy expenditure is one way of evaluating nutritional adequacy and future probability of over- and under-nutrition (Whitney and Rolfes, 2002). Energy expenditure may be determined via the use of doubly-labelled water (Schoeller, 1988) or the flex-heart rate method (Spurr et al., 1988). Additional methods include evaluating physical activity as it relates to duration, work intensity, pace, sustainability, and productivity (Panter-Brick, 1993; Dufour and Sauther 2002). However, this study will employ measurements of physical growth, or anthropometric indices, to assess nutritional status.

Anthropometric indices are dependable and sensitive indicators of growth and development. They are easily implemented to measure nutritional status because of their precision and repeatability, and the numerous sources of reference standards of comparison (Goodman, Dufour, and Pelto, 2000). Consequently, simple measures of height and weight, when compared with information on sex and age, produce reliable information on nutritional status (see Dufour, 1992; Galvin, 1992; Orr, Dufour, and Patton, 2001). Well-nourished children from various ethnic and cultural backgrounds follow similar patterns of growth (Martorell and Habicht, 1986), enabling the use of reference populations of similar growth potential to assess nutritional status.

2.6.1.2 Reference Populations

Waterlow et al (1977) encourages the use of a reference population when comparing anthropometric measurements. The reference population should be associated with a well-nourished population, include at least 200 individuals in each sex and age group, be cross-sectional, and include defined and reproducible sampling procedures (Waterlow et al., 1977). Wilson and Bulkan (2004) compared the Makushi described herein to reference populations developed by the United States National Centre for Health Statistics (NCHS), specifically the National Health and Nutritional Examination Surveys I and II (NHANES) (NCHS, 1977).

2.6.1.3 Use of Physical Growth Measures

Growth measurements are frequently used to assess nutritional status. Measurements of weight and height are used to compare children in a study population with a reference population. A low weight measurement indicates that the individual is suffering from under-nutrition when the data were recorded (Waterlow, 1977). Under-nutrition is a deficiency of calories or of one or more essential nutrients and may result from one or a combination of the following factors: lack of access to food, medical conditions requiring a greater need in energy intake, or disorders that interfere with metabolism (Goodman, Dufour and Pelto, 2000). Weight-for-height is considered an indicator of present nutritional status (Dufour, 1992). An individual who falls at the bottom fifth percentile for weight-for-height is classified as wasted. Wasting is suggestive of acute nutritional inadequacy (Waterlow, et al., 1977).

Height, or stature, is the vertical distance measured from a standing surface to the top of the head with a vertical and straight measuring rod or a stadiometer (Goodman, Dufour and Pelto, 2000). Height-for-age is an indicator of growth over time or nutritional history (Dufour1992; Stinson, 2000). An individual who falls at the bottom fifth percentile for height-for-age is classified as stunted. Stunting is suggestive of long-term nutritional inadequacy, and/or unfavourable environmental conditions, particularly ones in which chronic disease and infection are common (WHO, 1986).

As weight and height measurements are typically used in conjunction with a standardised growth velocity curve, these measurements are less informative for adult subjects, who have completed growth (WHO, 2002). As a result, adult health and nutritional status is frequently assessed using body mass index (BMI), which can be computed with the standardised formula weight (kg) / height $(m)^2$. BMI comprehends stature and weight simultaneously, yielding a more complete measurement of overall body size (WHO, 2002).

2.6.1.4 Aetiology of Variation of Physical Growth

Both within and between populations, there are numerous biological and cultural factors influencing growth variation. Although growth has a substantial and obvious genetic component, the genes that influence body size and shape are not well understood (Stinson, 2000; Hales and Barker, 2001). Sex differences in bodily growth may be determined by genes, and sensitivity of growth to environmental factors may be sex dependent (Stinson, 1985).

In addition to nutritional factors, research suggests that hormonal factors may play a role in small body size among some populations. For example, Geffner and colleagues (1995) found that the Efe pygmies of central Africa appear resistant to the growth-advancing effects of the hormone insulin-like growth factor I (IGF-I), because they have a lower number of sites for the hormone to attach to cells. Again, the genetic causes responsible for this hormonal feature are not known (Stinson, 2000).

The thrifty phenotype hypothesis (Hales and Barker, 2001) makes a connection between the foetal environment and physical growth. The hypothesis suggests that poor foetal nutrition, affected dramatically by maternal under-nutrition, sets in motion a 'thrifty' nutritional practise that has a dissimilar impact on different organs, thus causing altered growth and permanent changes in bodily structure and function (Hales and Barker, 2001).

The negative influence of disease on physical growth has been documented in numerous populations. Dufour (1992) reports that disease, in combination with diet, is accountable for growth deficits among Amerindian children. Wilson et al. (1999) report that Colombian boys infected with gastrointestinal parasites have significantly lower weight, stature, and weight-for-height than uninfected boys. In a recent study, Panter-Brick et al. (2004) have shown that growth faltering in a group of children from the United Kingdom resulted from chronic or frequent disease episodes and immunostimulation.

2.7 Growth and Development in the Amazon

Given the seasonal variation in food availability and energy expenditure described above, it is clear that nutritional status can be influenced by seasonality. One goal of this research is to determine whether or not seasonality in the Rupununi region affects Makushi growth. The following provides a review of nutritional and growth data for indigenous peoples of South America's lowland tropics such that the situation among the Makushi can be viewed in light of the larger context of the region.

The variation in body size, shape, and diet among the indigenous populations of South America's lowland tropics has been examined by a number of researchers (Stinson, 1990; Dufour, 1992; Dangour, 1995; Orr, Dufour and Patton, 2001). Stinson (1990) studied anthropometrics of 62 groups and found that Amazonian indigenous people have a small body size, with a mean height of 159 ± 4.7 cm for males and 148 ± 4.2 cm for females. Height was negatively correlated with precipitation. This is considerably shorter than adults from a North American reference population, which have a mean height of

177 ± 7.3 cm for males and 163 ± 6.2 cm for females (Dangour, 1999). Hence, Dufour's (1992) survey of anthropometric literature on Amazonian population reports that the mean height for both males and females is below the 10^{th} percentile for healthy adults in the United States. Dangour (1999:1), reporting on data collected from 1994 through 1999 on the nutritional status of several indigenous populations inhabiting the interior of Guyana, states that the mean heights of Patamona and Wapishana males are 158.6 ± 5.0 cm and 161.0 ± 4.8 cm, respectively, and the mean heights of females are146.6 ± 4.5 cm and 150.7 ± 4.4 cm, respectively. The mean heights of male and female Patamona and Wapishana demonstrate that these populations are close to the means reported for other groups in South America's humid tropics (Stinson, 1990). The aetiology of this apparent growth retardation is unclear.

In an analysis of height for age of children, Dufour (1992) notes that Amazonian children are generally short; 16% of the Mekranoti of northern Brazil, 26% of the children living in San Carlos de Rio Negro, Venezuela, and 50% of the Tukanoan children of the Colombian Vaupés region are <90% of the standard of height-for-age (Dufour, 1994). In agreement with Stinson (1990) and Dufour (1992), Dangour (1995) found that 35% of Guyanese Patamona children (aged 0-17 years) are stunted. The height of newborns is around the 50^{th} percentile, but by age two the infants are near the third percentile, which indicates that stunting occurs during the first two years of life (Dangour, 1995). The mean height of Patamona males and females between the ages of two and 18 was below the third percentile, indicating a continuing stunting trend or a lack of catch-up growth (Dangour and Ismail, 1997). Therefore, Dangour and Ismail

(1997:11) suggest that insufficient dietary intake and a high rate of illness and infectious diseases, rather than genetic potential, are the factors detrimentally affecting height growth among Patamona children. Dufour (1992) reports that, in terms of weight-for-height, indigenous children and adults are in the normal range with low percentages of wasting. Also in agreement with Stinson (1990) and others, few Guyanese Patamona (2% of children aged 0-11 years) were wasted (Dangour, 1995).

As noted above, BMI is often used to provide a more comprehensive assessment of nutritional status among adolescents and adults. Male Patamona and Wapishana adults aged 20.0 to 49.9 years have mean BMI measures of 23.0 ± 1.7 and 23.8 ± 1.8, respectively, and female Patamona and Wapishana female adults of the same age have mean BMI measures of 22.6 ± 2.1 and 23.3 ± 2.9, respectively (Dangour, 1999). Although leaner than their North American reference group (25.6 ± 3.8 for males and 24.3 ± 5.0 for females), the Patamona and Wapishana BMIs fall into a healthy range (Dangour, 1999).

Dangour (1995) and Dufour (1992) suggest that the small adult stature of Amazonian people may be due to the nutritional composition and variety of their diets. Dufour's (1992:202) study of dietary intake of Tukanoan adults in the Colombian Amazon documents that "mean energy intakes are 100% or more of FAO/WHO (1973) recommendations for moderately active adults" and "appear adequate in comparison to estimates of energy expenditure". Although adequate in energy and protein, the diets are high in bulk and low in caloric density, which may account for decreased growth rates, especially in children (Dufour, 1992). In a report on the nutritional status of the

Wapishana and Patamona Indians of Guyana, Dangour (1999) suggests that high household farm crop diversity is correlated with improved childhood growth and that an expanded variety of farm crop products could ameliorate the nutritional inadequacy of diet and, subsequently, improve growth performance. Therefore, the diversity of household farm crops, which may be influenced by season, may enhance the nutritional adequacy of the diet.

Dietary adequacy is linked to changes in season. As noted above, seasonal variation in subsistence strategies, patterns of physical activity, and nutritional requirements have been documented among numerous pastoral and horticultural populations. Anthropometric indices are used to assess nutritional status and variation in physical growth. The following section will employ studies of seasonality and nutrition, coupled with knowledge of growth and development in the Amazon, to evaluate the impact of seasonality on the dietary intake of the Makushi Amerindians of Guyana.

CHAPTER THREE: SUBJECTS AND SETTING

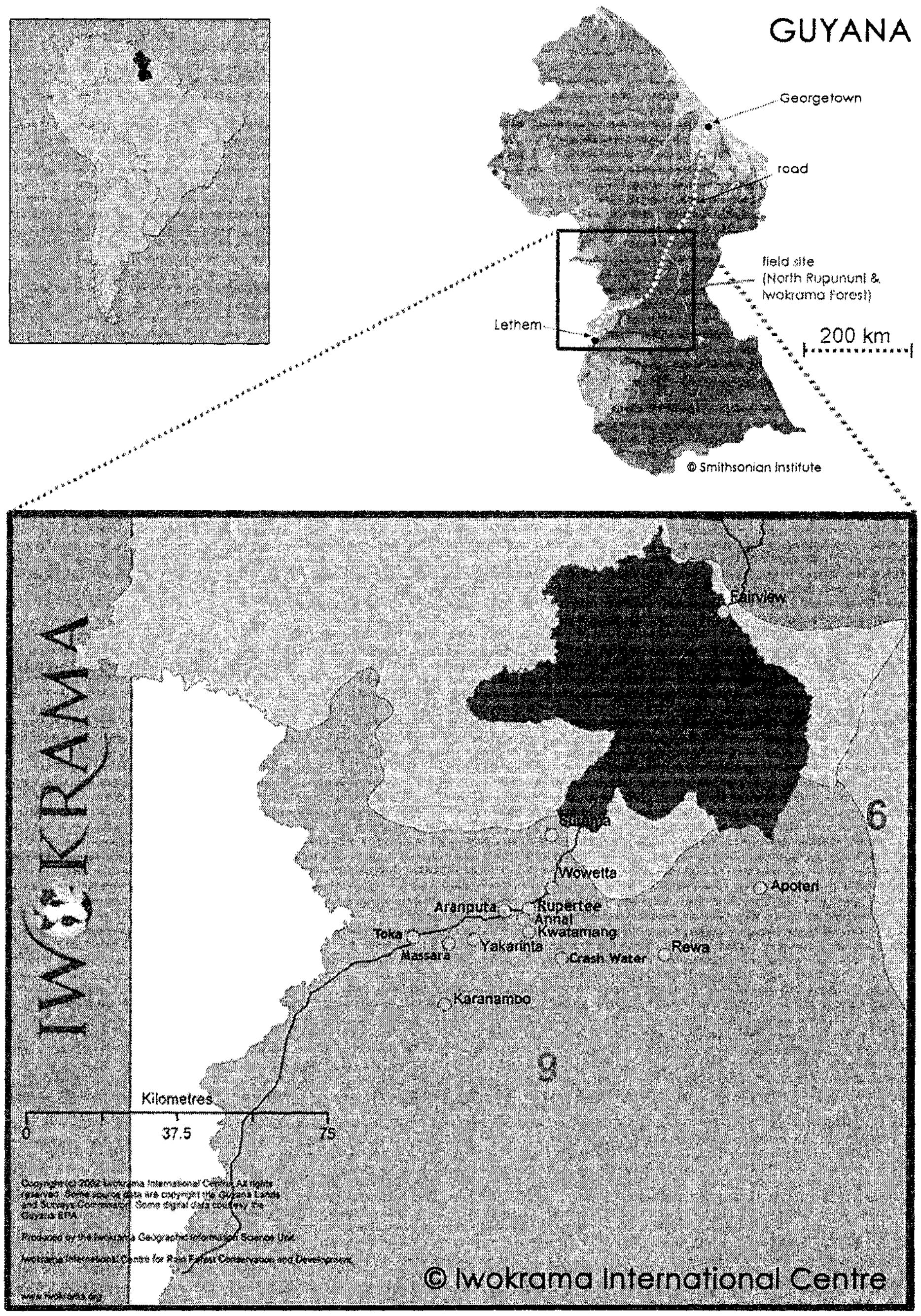
3.1 Study Area

3.1.1 Background: Indigenous Populations of Guyana's Interior

Guyana, situated on the north-eastern shoulder of South America (Figure 3.1), was colonised first by the Dutch in 1621 then by the British in 1803, and gained independence in 1966, at which time the name was changed from British Guiana to Guyana (Colchester, 1997). During the late 19^{th} century, explorer Everard Im Thurn (1883) counted 15 Amerindian groups living in British Guiana. In 1840, and again in 1881, attempts were made to estimate the Amerindian population by counting those living along the riverbanks of the Pomeroon, Moruca, Waini, and Barrama rivers. From this, the Amerindian population of British Guiana was estimated to number between 12,000 and 20,000 (Im Thurn, 1883). At present there are nine Amerindian groups including the Akawaio, Arawak, Arecuna, Carib, Makushi, Patamona, Wai Wai, Warrau, and Wapishana, with a total population of 49,293 persons representing 6.8% of the population of Guyana (Guyana census, 1991).

The nine Amerindian groups occupy four different geographical regions of Guyana. The Arawak, Carib and Warrau reside in the low, narrow coastal plain; the Patamona, Arekuna and Akawaio in the highland mountainous region in the mid-west; the Wai Wai in the forested areas to the south; and the Wapishana and Makushi in the savannahs and forests of the Rupununi region located in the central south-west of Guyana (Dangour, 1995).

Figure 3.1 Map of Study Area



3.1.2 North Rupununi

There are 27 principal Makushi villages in Guyana, 24 of which are located in Region 9 (North Rupununi) (Forte, 1996). Makushi territory is bordered on the south by an east-west stretch of the Kanuku Mountains, on the east by the Essequibo River, and on the west by the Takatu River and Ireng River systems that mark the international border with Brazil (Figure 3.1). The Makushi are the most populous of the six Carib-speaking peoples of Guyana, with a total population estimate numbering between 7,000 and 9,000 (CIR, 1993; Forte, 1996). Thirteen villages, ten of which form the basis of this study, are represented in the North Rupununi District Development Board (NRDDB), and comprise 30 percent of the total Makushi population (Forte, 1996). While most villages are predominantly Makushi, several are populated by a mix of other indigenous groups or migrants from Guyana's coast.

Schomburgk (1922) proposed that in the mid-16th century the Makushi migrated from the Orinoco Basin to the Upper Essequibo region to escape conflict with other Carib groups and the Spanish. Historically, the presence of the Makushi in the Rupununi region dates to the early 18th century when the area was exposed to colonial rivalries among the Spanish, Portuguese, English, and Dutch occupiers (Santilli, 1994). The Makushi resisted attempts by the Portuguese military to settle, until the nineteenth century development of cattle ranching increased land shortages and hard labour requirements. These occurrences rendered the Amerindians dependent on their employers for government interaction and trade, thus, forming a class-defined stratified society (Colchester, 1997). By the 1940s, an estimated million hectares, or two thirds of the total area, of the Guyanese savannahs were no longer under Amerindian ownership (Colchester, 1997). Today, several Makushi villages have legal land titles, but others are known as untitled settlements (Bulkan, 2003) and are not recognised as owners of their lands (see Section 3.14).

3.1.3 Demographics of the North Rupununi

Table 3.1 summarises some of the demographic data, including adults and children, for the villages considered. The average village population in 2003 was 318 ± 135 persons.

Table 3.1 Total population of ten Makushi villages from 2000-2003 (Annai Medical Centre, 2003)

	2000			2001			2002			2003		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Annai	212	206	418	214	209	425	213	214	427	218	219	437
Aranaputa	222	209	431	226	212	438	n/a	n/a	448	251	220	471
Crashwater	81	85	166	94	89	183	95	89	184	96	87	183
Fairview	60	42	102	62	47	109	63	45	108	75	55	130
Kwataman	160	161	321	169	163	332	223	116	339	176	147	323
Massara	175	154	329	177	156	333	n/a	n/a	335	186	159	345
Rupertee	119	114	233	120	116	236	131	113	244	131	119	250
Surama	93	95	188	99	105	204	108	114	222	112	112	224
Wowetta	127	116	243	142	115	257	112	117	229	144	120	264
Yakarinta	257	242	499	258	246	504	n/a	n/a	517	269	284	553
Total	**1056**	**1424**	**2930**	**1561**	**1458**	**3021**	**945**	**344**	**3053**	**1658**	**1522**	**3180**

3.1.4 Current Legal Status of the Makushi Villages

Ten Makushi villages are included in this study: Annai, Aranaputa, Crashwater, Fair View, Kwataman, Massara, Rupertee, Surama, Wowetta, and Yakarinta.

In 1976, the five Makushi villages that comprise Annai District, Annai, Kwataman, Rupertee, Surama, and Wowetta, were granted legal title to their village and farm lands by the Guyanese government (Bulkan, 2003). The Makushi villages of Massara and Yakarinta also hold land titles, but, in 1997, refused an offer from the government to have their current titled lands demarcated, maintaining that extension of existing titles was necessary (Bulkan, 2003). Aranaputa's land settlement design was planned in the 1950s and residents have long-term leases. Crashwater is an untitled village that has not been visited by the Amerindian Lands Commission since 1996. Fair View is situated on an area of land for which the lease has lapsed, and its proximity to the Iwokrama field station and the Georgetown to Lethem Road (Figure 3.1) has attracted numerous settlers (Bulkan, 2003).

3.1.5 Iwokrama and the North Rupununi District Development Board

The Iwokrama International Centre for Rain Forest Conservation and Development (Iwokrama) was established in 1993 by Guyana and the Commonwealth. Iwokrama manages the one million acre Iwokrama Forest on the northern edge of the Rupununi region (Figure 3.1) to demonstrate how tropical forests can be conserved and used in a manner which is both sustainable and economically beneficial to the peoples of the region. Toward this end, Iwokrama works in partnership with neighbouring villages through their representative board, known as the North Rupununi District Development Board (NRDDB).

The NRDDB, established in 1996, is an Amerindian community-based organisation composed of village leaders and Amerindian representatives. Iwokrama helped create the NRDDB to establish a formal link between the communities, government agencies, and Iwokrama. NRDDB representatives take responsibility for the planning and co-ordination of numerous educational, developmental, cultural and research programmes in the North Rupununi.

3.1.6 Accessibility

The North Rupununi region is accessible by air via a one-hour aeroplane flight from Georgetown (pop. 350,000), Guyana's capital city. The airstrip is approximately 420 km SSW of Georgetown and is located between the villages of Annai and Rupertee. Alternatively, with a four-wheel drive vehicle one may drive from Georgetown on a marginal dirt road, a journey that takes a minimum of eight hours during the dry season and up to three days during the wet season. The nearest town, Lethem (pop. 2,600), is 120 km SW located on the Brazilian border, may be reached by dirt road in approximately four hours. The relatively modern city of Boa Vista in Brazil is located approximately 1.5 hours from Lethem by vehicle and some Makushi spend time there working as domestic help or as ranch hands. Trucks transporting goods between Lethem and Georgetown pass through the North Rupununi about three times a week. The truck drivers often sell products such as rice, flour, cookies, and soda pop to shopkeepers in several of the villages. In addition, as some villagers in Aranaputa grow peanuts for sale, the trucks transport the peanuts to markets in Georgetown.

Development of the North Rupununi region is largely dependent on plans to transform the dirt road linking Georgetown and Lethem into a paved highway. Paving the 540 km long dirt road will ease wet season travel within the region, when the dirt road usually becomes flooded, and may increase economic opportunities for the inhabitants of the North Rupununi. However, it also raises concerns regarding the environmental and cultural impacts (Colchester, 1997; James, 2001). Environmentalists and others warn that the road could lead to an influx of people from neighbouring countries or from the coast, resulting in cultural degradation, land conflict, and irreversible harm interior Guyana's ecology (Colchester, 1997; James, 2001).

3.2 Ecology

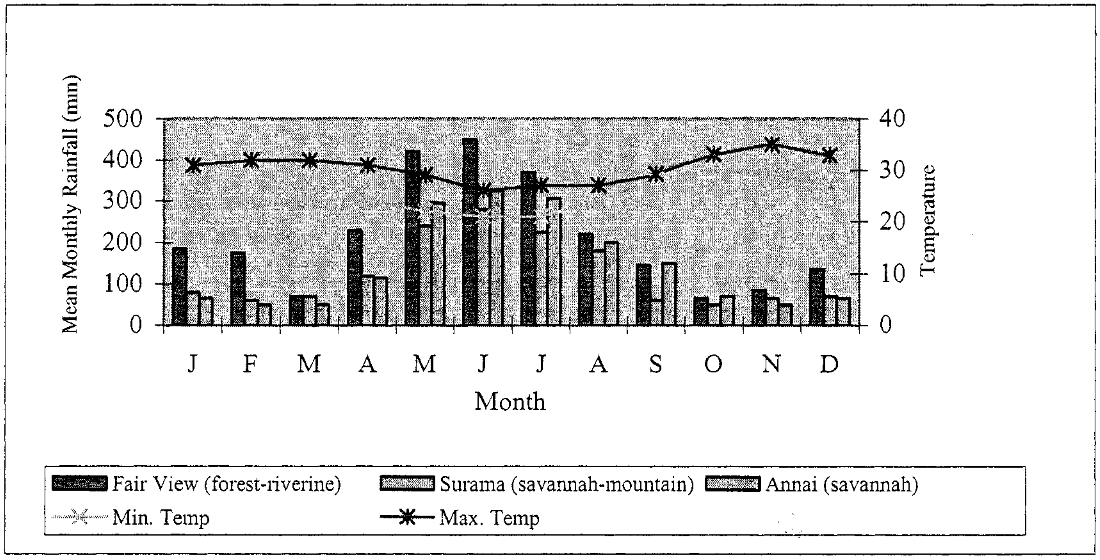
3.2.1 Climate

The North Rupununi region is located between 2°N and 4°N and 59°W and 60°W (Frost, 1968) and is composed of rainforests in the north and savannahs in the south, with blackwater and whitewater drainages. Locations within the Rupununi region are commonly dry, hot, and humid. The mean monthly maximum temperature varies from 30°C and 33°C in October, while the minimum ranges from 22°C to 25°C in July (Frost, 1968). The daily temperature range in October is from 29°C to 33°C, and in July from 22°C to 27°C. The average relative humidity is 70% in the savannah, but is highest during early morning hours (0100 to 0400 hours) and lowest during mid-day hours (1200 and 1400 hours), regardless of season (Iwokrama 2003).

The climate of the Rupununi region is comprised of a seven-month dry season, lasting from mid-October to mid-May (Iwokrama, 2003). The driest months of the year are October through March with rainfall amounts averaging 50mm per month (Iwokrama, 2003). The long wet season occurs from mid-May to September, and a short wet season spans December and January (Figure 3.2). Mean annual rainfall ranges from 3,000 mm in the rainforests to 1,400 mm in the savannahs. During the long wet season mean monthly rainfall accumulation typically exceeds 300-400mm, but can reach 100mm in a single day (Frost, 1968; Iwokrama 2003). It is the length and depth of the dry season trough that characterises the savannah. Total annual rainfall amounts decline from northeast to southwest following the main Fair View to Annai road alignment, which is due to a change from an Intertropical Convergence Zone-influenced double-peaked rainfall pattern to one that is single-peaked and continental in nature (Iwokrama 2003).

Based on geographical location and the natural bounty of the river and forest to provide fishing, hunting and farming areas, the Makushi villages occupy four different ecotones which affect the distances that have to be travelled to arrive at farms and fishing and hunting grounds (Wilson and Bulkan, 2004). Annai, Rupertee, and Yakarinta occupy a savannah ecotone that is characterised by outcroppings of high land amidst low ground that floods seasonally; Surama and Wowetta are savannah-forest ecotone villages situated on the flat savannah surrounded by forest; Aranaputa belongs to the savannah-mountain ecotone and is situated on flat savannah at the foot of mountains; and Kwataman, Fair View, Crashwater, and Massara are forest-riverine villages located in the forest along a whitewater river, or, for Fair View, a blackwater river (Wilson and Bulkan, 2004).

Figure 3.2 Mean Monthly Rainfall and Temperature[1] in Three Makushi Villages and Ecotones (Frost, 1968; Iwokrama, 2003)



[1]The period considered for each village ranges between 1971 and 1999.

3.2.2 El Niño

Precipitation amounts in the rainforest and savannah are highly responsive to El Niño climatic events, which occur every six to ten years (Iwokrama 2003). El Niño events, which, according to palaeoclimatic data, have been occurring since before 4000 B.P, cause rainfall anomalies in South America, and lower than average rainfall amounts in central northeast Amazonia (Martin et al., 1993). El Niño occurrences are generated by two main causes: 1) a westward shift in the convection zone, normally situated on Amazonia (Wyrtki, 1982), and 2) a stoppage of polar front systems from southern Peru to southern Brazil, resulting in drought in northern regions of Amazonia (Kousky et al., 1984). These events tend to occur when the "the Southern Oscillation Index – calculated as the atmospheric pressure in Tahiti minus the atmospheric pressure in Darwin, Australia – is negative" (Van Buren, 2001, p 134). Heavy rains, typical of the months

June through August, can be reduced by 50%, and a two to four week drought often occurs during the dry season months of February and March in the most northern parts of the Rupununi (Iwokrama 2003). In the southern parts of the northern Rupununi rainfall is severely sparse from October through March, and extreme El Niño events prevent rainfall for several months (e.g. 1940-41, 1983-84, and 1997-98) (Iwokrama 2003).

In 1998, Guyana experienced a six-month drought due to El Niño (CIDI, 1998; *The Economist 4/25/98*). This national emergency ruined manioc crops in the Rupununi region, and killed other fruit and vegetable crops grown by the villagers. In Aranaputa, cash crops of peanuts dried up, significantly reducing, if not eliminating monetary gain. In an effort to address the loss of manioc culitvars, Guyana's civil-defence authorities imported manioc roots from Brazil, and had planned to send a biweekly food parcel to each family inhabiting interior Guyana (CIDI, 1998; *The Economist*, 1998).

3.3 Makushi Resource Management and Subsistence Strategies

3.3.1 Horticulture

Makushi villages share a problem of insufficient arable land. Makushi farms are cleared areas of uncultivated land or secondary forest, ranging in size from 400 m^2 to more than 1 hectare (Elias, Rival, and McKey, 2000). Given the lack of arable land near many of the villages, the inhabitants must travel by foot or canoe for anywhere between one hour to one day to reach their farms. Farm management practises are mainly concerned with protection from predators and environmental factors (flooding and drought), and seem to influence the choice of farm sites more so than soil fertility (Forte, 1996; Elias, Rival, and McKey, 2000).

The Makushi diet, mirrored largely by the Tukanoan and Patamona Amerindians, is based primarily on a staple crop of bitter manioc (*Manihot esculenta* Crantz), a perennial woody shrub of the Euphorbiaceae that is well-adapted to the nutrient poor, highly acidic soils that are common throughout Amazonia (Elias, Panaud and Robert, 2000; Wilson and Dufour, 2001). Manioc can be roughly classified as "sweet" or "bitter" on the basis of the cyanogenic potential (CNP) of the root. "Sweet" or low-CNP manioc [root CNP less than 50 mg kg^{-1} as HCN (hydrolizable cyanide in fresh weight basis)] is generally considered safe for consumption with only basic processing (e.g. peeling and cooking), while "bitter" or high-CNP manioc [root CNP greater than 100 mg kg^{-1} as HCN] must be processed prior to consumption to eliminate the cyanogens or reduce them to physiologically tolerable levels (Cooke, 1983; Dufour 1988). The Makushi rely primarily on "bitter" manioc, which they call *kîse* (Forte, 1996; Elias, Rival, and McKey, 2000). Of the over 5,000 known varieties of *Manihot esculenta* the Makushi possess at least 76 of the bitter varieties (Elias, Rival, and McKey, 2000).

Planting and harvesting of manioc plants occur sporadically throughout the year (Elias, Rival, and McKey, 2000). Most planting coincides with the beginning of the wet season (April – May), followed by daily or weekly visits to the farm to plant smaller amounts, while weeding among growing plants. The Makushi take advantage of the rains by continually planting throughout the long wet season, and again during the short November – December rains. Manioc roots are generally harvested after nine months, but may remain unharvested for up to two years (Forte, 1996; Elias, Rival, and McKey, 2000).

There are several types of food made from manioc. The initial step in the processing for most manioc food items is a lengthy operation entailing soaking and grating the roots, then straining the grated roots in a *matapi*, a long plaited sleeve press. *Farine*, a granular meal, is made from a mixture of fresh-grated manioc roots and roots that have fermented for three days. This mixture is squeezed, sifted to remove the larger pieces and then parched for two hours. The liquid produced in the initial processing, manioc water, is heated to separate out the manioc starch, which is then finely sifted and parched for an hour to produce white, granular *tapioca*. *Casareep*, indigenous gravy browning, is made from manioc water that is boiled for up to 12 hours until it thickens and becomes dark brown in colour.

Manioc plants predominate in the Makushi diet, but several other cultivated plants (scientific names are provided where possible) including corn (*Zea* spp .), yam (*Dioscorea* spp.), sweet manioc (*Manihot esculenta.*), plantain (*Musa paradisiaca*), dasheen (*Colocasia* spp.), peanuts (*Arachis hypogaea*), and eddoe (*Colocasia* spp.) are frequently consumed (Forte, 1996). These crops are planted intermittently amongst the manioc plants to benefit from pest management, increased usage of farm area, and commensalism (Forte, 1996).

3.3.2 Non-domesticated Plant Foods

Forte (1996) reports that wild foods are available to the Makushi on a seasonal schedule. Numerous fruits, such as mango (*Mangifera indica*), ite palm fruit (*Mauritia flexuosa*), jamoon (*Syzygium cumini*), lu palm (sp. unknown) and citrus fruits (e.g. *Citrus aurantifolia*, *Citrus sinensis*) are consumed in the dry season, and wild foods fruit in the early to middle rainy season. The cashew (*Anacardium occidentale*) tree fruits between December and February, whereas the wild cherry (sp. unknown) fruits in October/November and March/April. Succulent palm and forest fruits, such as whitey (sp. unknown), balata (*Mimusups* balata), kokerite (*Maxmiliana regia*), and jamoon (*Syzygium cumini*) ripen in February (Forte, 1996).

3.3.3 Fish and Game

While manioc appears to provide the bulk of the energy in the diet, dietary protein comes primarily from fish and game (Forte, 1996). The Makushi depend more on fishing than hunting for dietary protein, and engage in fishing practises during most months of the year (Forte, 1996). Fish behaviour is dependent on levels of rainfall, and the Makushi adapt their fishing strategies likewise. For example, dry season fishing occurs in rivers and creeks of the Rupununi with hook and line, homemade gill nets, bow and arrow, and fish traps. Makushi knowledge of fish foods, mating schedules, and behavioural patterns is necessary during the high water of the wet season when rapid waterways and lower fish densities render fishing difficult.

Makushi men hunt throughout the year around their farms where the ripening of crops entices game (Forte, 1996). The Makushi men hunt two to three times per week during the wet season, when fishing yields are low and small islands of dry land created by savannah flooding trap game animals. Hunting catches are highly variable in size and frequency. Small catches occur often and usually provide for one household, while large catches, occurring less frequently, may be shared with or sold to village members who are without. The duration of hunting trips and the amount of meat collected has not been quantified; rather,this data has been generated via anecdotal accounts (Forte, 1996). During the early rainy season (May) the Makushi will stalk birds feeding on fruits beginning to ripen in both forest and savannah locations. However, Forte (1996) reports that most birds are consumed during the months August – November.

3.3.4 Seasonal Variation in Food Supplies

Forte (1996:49) reports that "while there is seasonal variation in the activity patterns of the Makushi producers - more fishing trips in the dry season, more wild fruits gathered in the rainy season - the amount of time devoted to food acquisition does not vary significantly from rainy to dry season". (Note, the term "significantly" as used here does not denote statistical significance; rather, it is used by Forte in the vernacular.) The Makushi have a continual supply of manioc roots throughout the year, provided adequate annual rainfall. The dry season is characterised by daily fishing trips, weeding, planting, and maintenance trips to the farm. The frequency of farm visits depends largely on the distance of the farm from the home village. Savannah inhabitants have to travel the furthest to their farms and lack easily accessible supplementary gathered foods (Wilson and Bulkan, 2004). Despite the difference in mean monthly rainfall amounts (see Figure 3.2), planting schedules of villages in the northern rainforest areas resemble those of villages in the southern savannah. Regional variability exists regarding the availability of wild forest fruits and vegetables (Forte, 1996).

The wet season is characterised by weekly hunting trips and a greater abundance of collected wild fruits and vegetables. Figure 3.3 outlines the calendar of traditional, seasonal subsistence strategies among the Makushi. This section summarises what we know of the seasonal subsistence strategies of the Makushi and this thesis will explore this subject in greater depth.

3.3.5 Domesticated Animals

Numerous Makushi villages raise livestock. The Makushi care for animals such as cows, horses, sheep, donkeys, pigs, and chickens. Eggs and milk are consumed regularly, and sold or traded throughout the village. In villages where livestock are owned collectively, cows are slaughtered on special occasions (e.g. Christmas) to benefit all village members (Forte, 1996).

3.3.6 Store-Bought Foods

All Makushi villages surveyed have access to store-bought food items. Although there is little economic activity at present, the principal methods of money-making include selling food items such as fish, meat, or nuts, selling home-made crafts, village work as labourers or teachers, and work as wardens and cooks with Iwokrama. Available food supplies in the stores vary considerably as they are dependent on shipments from Brazil or Georgetown and road conditions, which vary seasonally.

Income permitting, most women purchase dry goods (sugar, flour, rice, coffee, etc.) weekly and fresh produce (meat, garlic, onions) monthly (Forte, 1996; Wilson, pers. comm.). The women do most food preparation in their own kitchens and family members consume most meals at home (Forte, 1996).

Sections 3.1 through 3.3 have provided some background on the Makushi, the region in which they live, and their subsistence practises. The Methods chapter that follows will detail the protocol used to assess the potential impact of seasonality on the Makushi diet.

Figure 3.3 Calendar of seasonal subsistence strategies of the Makushi.

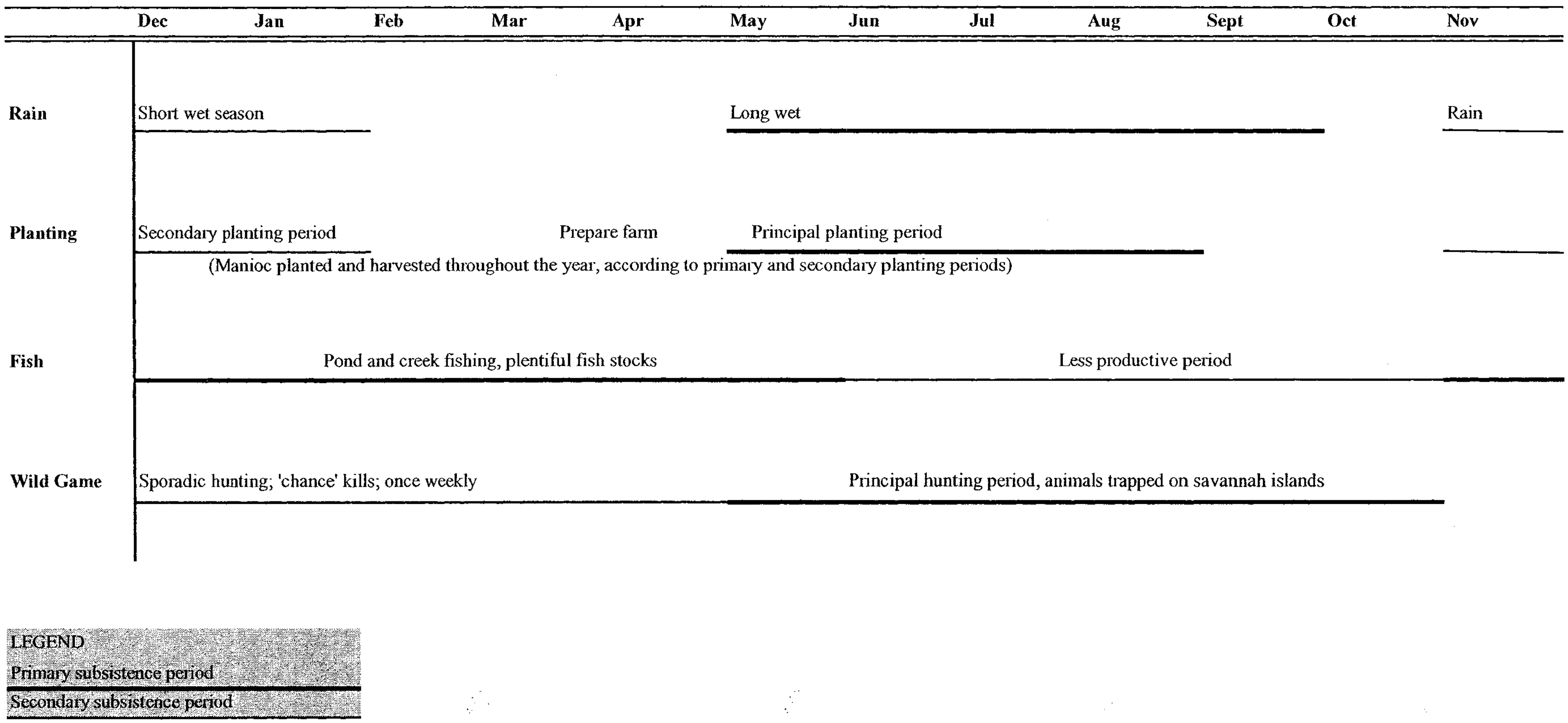


Figure 3.3 cont. Calendar of seasonal subsistence strategies of the Makushi.

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov
Wild Foods	jamoon		plum	locust, cherry		whitey, papaya, wild passion fruit, hitcha, lu, mango					orange (through December)	
	mango		balata fruit	lime, lemon				kokerite		plum		wild cashew
Cultivated Foods	guava		cashew	spice mango (unripe)		banana, pineapple		sweet manioc		yam	callaloo	tomato, belanger
											through January cashew, purple potato dasheen, eddoe	

LEGEND
Primary subsistence period
Secondary subsistence period

CHAPTER FOUR: METHODS

4.1 Data Collection

This research utilises data collected in two different manners and time periods: 1) 24-hour dietary recall data collected in 2000-2001 and 2) interview data on dietary seasonality collected in 2003.

4.1.1 24-Hour Dietary Recall Data

Twenty-four hour dietary recall data are a logistically simple measure to account for all foods and beverages consumed from midnight to midnight over the past 24-hour period. The 24-hour recalls involve a reasonably acceptable respondent burden, are person-specific, and, for large sample populations, provide estimates of average food intake comparable to more thorough methods (Beaton et al., 1979; Ahluwalia and Lammi-Keefe, 1991). The estimates of average food intake can be evaluated with respect to dietary recommendations. Buzzard (1998:50) reports that "...in some instances, such as when comparing nutrient intakes with specific dietary recommendations, estimates of absolute energy and macronutrient intakes may be required. In such cases, records or recalls are generally the method of choice."

The 24-hour recall data were collected by a woman from each of the thirteen Rupununi villages. These women are collectively known as the Makushi Research Unit (MRU). The women were originally organised by cultural anthropologist Jannette Bulkan to collect a variety of data for Guyana's Ministry of Health and the University of Guyana's Amerindian Research Unit. Each member of the MRU collected data in her village.

For this particular study, Wilson and Bulkan spent two weeks in 2000 training the MRU to collect 24-hour dietary recall data. Both MRU members and subject households were paid for their participation in the study. Each member of the MRU was asked to collect data for three to five households in their villages. Each household was to be interviewed twice each month over a one-year period from July 2000 to June 2001. One of the interviews was to be held on Monday through Thursday and another on Saturday. Subjects were not interviewed on two consecutive days.

Households chosen for the dietary recall interviews had to meet several criteria. Each household had to consist of a female with at least one child, a second individual greater than 12 years of age, and a child aged between birth and four years (a time during which the child remains almost exclusively with the mother). Finally, the households included could not be earning a regular income. The MRU collected information for a minimum of three people in each household, including the mother, the child under four years of age, and a second adult. In several villages, dietary intake surveys are not recorded for all age and sex groups. The father was frequently chosen as the second adult, thus leaving the adolescent age group (13-19 years) with no recording.

The MRU recorded the subject's name, date of interview, home village, sex, birthdate, number of children, as well as name, age, sex of the children. The dietary data forms required breastfeeding status, a brief activity summary, and a list of quantities of all foods and beverages consumed during the previous midnight to midnight period. Foods and beverages were subsequently classified by item, category, type, and preparation. For example, flour porridge (item) would be followed by cereal grain (category), flour (type), and porridge (preparation).

Nutritional values of most foods and beverages consumed were computed with the nutrient database of Nutritional Analysis Tool (NAT) 2.0 based on the United States Department of Agriculture Handbook #8 (2002). In several instances, NAT 2.0 lacked specific foods consumed by the Makushi. These include several fish species, wild fruits such as conkee, corro, whitey, kokorite (*Maximiliana regia*), and awara, and a fermented manioc beverage, *parakari*. For each of these, a similar food contained in NAT 2.0 and its nutritional values were determined as a suitable substitute for the missing food. The Makushi regularly consumed 33 different fish species, which fell into three general fish types: catfish, characins (toothy fishes), and perch-like fish. Catfish was used as the substitute for all fish species closely related to catfish; swordfish for all characins; and sea bass for perch-like fishes. Jamoon, or java plum, (*Syzygium cumini*) was used as a substitute for conkee, corro, kokorite, and awara as descriptions of these wild fruits were similar. Fat pork, or coco plum, was used as a substitute for whitey, as they have a similar appearance and may be the same fruit. Regular beer was substituted for *parakari* in the nutritional analysis as the vitamin and alcohol contents of regular beer were approximately the same as those of similar fermented beverages at time of consumption (Steinkraus, 1979). The nutritional values for several additional foods were found in separate databases. These include dove (*Streptopelia risoria)* (USDA, 2004), mutton (Ntiamoa-Baidu, 1997), caterpillar (Dufour, 1987), hot sauce (USDA, 2004), *farine* (Wilson, unpublished data), and *casareep* (Nestle Foods, Inc., 2004).

Nutrients examined in the present study include energy, protein, fat, and vitamin A. Energy, fat, and protein were chosen primarily because they define the baseline in nutritional analyses. Vitamin A is investigated as vitamin A deficiency (VAD) is primary cause of blindness and increases the risk of disease and death from severe infection, among children, and puts pregnant women at a higher risk of maternal mortality (WHO, 2003). VAD is a public health problem throughout the world, affecting principally young children and pregnant women of low-income countries who may experience seasonally available food supplies (WHO, 2003).

Variation in dietary intake was assessed by analysing how many different food items were consumed each day, and the contribution of selected food types to the overall energy intake. Foods consumed were divided into the following food types: manioc, fruits/vegetables (wild and cultivated), game, fish, store-bought, insects, and alcoholic beverages.

In this study, 24-hour dietary recall data for one month of the dry season and one month of the wet season are compared. The one month considered for each season was selected because it fell within the generally outlined seasonal calendar. For the purposes of this study, dry season months include October, November, February and March, and wet season months included May, June, July, and August. The same months were not chosen for each of the ten villages studied as the 24-hour dietary recall data were missing for several villages for several months of the initial survey.

4.2 Reference Data

The percent recommended daily allowances (RDA) values were compared to recommendations proposed by the National Academy of Sciences (2001), and a joint collaboration of the Food and Agriculture Organization of the United Nations and the World Health Organisation (2002) (see Tables 2.1 and 2.2).

4.3 Semi-structured Interviews

The 24-hour dietary recall data are compared with responses of semi-structured interviews (see Appendix A) with an aim to test the reliability and validity of each interview strategy. Semi-structured interviews may also help determine whether or not the Makushi perceive any differences in dietary intake by season and, if so, what the consequences might be and how might they adapt to seasonal variations in food supply.

Semi-structured interviews are best suited for situations where there is only one chance to interview someone (Bernard, 2002). Following Pelto, Pelto and Messer (1989) and Bernard (2002), the semi-structured interviewing technique allowed for casual conversation while adhering to a list of questions and topics.

The interviews were scheduled at the convenience of the MRU, who facilitated the meeting in a public building, and organised other participants. The author conducted the interviews and, in four out of 10 cases, a second female. Nine of the ten of the interviews were conducted in English. The average interview duration was 45 minutes. The interviewees consisted of the community MRU and at least two female participants of the 24-hour dietary recall study. Women were interviewed, as they are responsible for kitchen gardens, household food preparation, and the cultivation of crops in the family farm (Forte, 1996).

Participants were asked for personal information and basic household-level variables. Personal information included name, age, number of children, and marital status, while household-level variables included the availability of money, education-level of children, and number of children living at home. Participants were encouraged to discuss foods commonly associated with the dry season and wet season, and foods consumed throughout the year. All Makushi villages visited have shops and some Makushi partake in the cash economy, therefore participants were asked about foods purchased and local prices. To gain knowledge of individual perceptions of seasonality, participants outlined general difficulties encountered during the wet and dry seasons.

4.4 Assumptions

The methodology of the present study observes the following assumptions: The two interview periods are each representative of an average month of nutritional intake during the respective wet and dry seasons. This study assumes that the 24-hour dietary recall surveys accurately report all food items and amounts that were consumed during the prior 24-hour period. It is assumed that the 24-hour surveys are a true representation of the nutritional intake of the participants and, as such, will be used in statistical analyses. It is assumed that food substitutions made in cases where the NATS 2.0 database lacked the nutritional composition of food items consumed by the Makushi will not affect the results as many of these foods were seldom consumed. Information gathered via semi-structured interviews is understood as valid.

4.5 Human Research

This project and protocols were approved by the NRDDB, Guyana's Environmental Protection Agency and Ministry of Amerindian Affairs, and the Conjoint Faculties Research Ethics Board at the University of Calgary. Informed consent was obtained from the *toushau*, or village leader, before subject interviews were conducted.

4.6 Data Analysis

The present study examines seasonality and nutritional adequacy, thus there is a focus on RDA. The percentages of each sex and age group with nutritional intakes less than 67% RDA were calculated. Participants with a RDA of less than 67% are considered as having an inadequate intake of that nutrient (Johnson et al., 1974; Omori and Greksa, 2002).

The data are presented as means, standard deviations (SD), and percentages unless otherwise indicated. Season, village, sex, and age were included as independent fixed variables. Two sample unequal variance t-tests were employed to test whether the wet and dry season population means were equal, to evaluate seasonal dietary variation, and to compare food item contribution and daily energy intake between seasons. One-way analysis of variance (ANOVA) was used to compare the uniseasonal mean intakes of energy, protein, fat, and vitamin A of the subjects in the 10 villages. Chi square, a non-parametric test for bivariate tabular analysis, was employed to ascertain whether the prevalence of food items recorded in wet and dry season 24-hour dietary recalls were statistically different. Boxplots and column abnormality checks were used to investigate homogeneity of variance and normal distribution among random effects. All P values are shown, with P values for principal effects and significant interactions presented in bold. T-values are not provided. All statistical analyses were performed with Excel 1997 (Microsoft, Redmond, WA). Results were considered statistically significant at $P \leq 0.05$.

CHAPTER FIVE: RESULTS

5.1 24-Hour Dietary Recall Data

5.1.1 Study Population

The 24-hour dietary recall surveys were evenly split between seasons with 49.5% from the wet season and 50.5% from the dry season (Table 5.1). The surveys are not evenly split between sexes, with 64.9% (469 of 723) of dietary surveys from females and 35.1% (254 of 723) from males.

Table 5.1 Number of 24-Hour Dietary Recall Surveys per Village per Season

	Season				
	Wet		Dry		
	Female	Male	Female	Male	Total
Village					
Annai	32	10	30	12	84
Aranaputa	7	9	26	13	55
Crashwater	26	14	16	8	64
Fair View	17	17	15	17	66
Kwataman	20	9	20	8	57
Massara	26	23	26	26	101
Rupertee	14	16	15	16	61
Surama	35	9	28	6	78
Wowetta	25	7	25	7	64
Yakarinta	32	10	34	17	93
Total	234	124	235	130	723
Average	23.4	12.4	23.5	13	
SD	8.9	5.0	6.7	6.2	

The 24-hour dietary recall study population used in this research was composed of 73 households in 10 villages. Due to outmigration, morbidity, and MRU selection, the wet and dry season 24-hour dietary recall populations are different. Sixty-five households participated during the wet season and 68 during the dry season. Sixty households participated during both seasons, while five additional households participated exclusively during the wet season and eight participated exclusively during the dry season.

There were 197 participants, comprised of 73 males and 124 females. The 24-hour dietary recall population consisted of 85 children aged 1-12 years (43% of total), 12 adolescents aged 13-19 years (6%), and 100 adults aged ≥ 20 years (51%). Of the women, seven were pregnant and 65 lactating. Breastfed infants were omitted because there is no available data concerning the frequency and duration of feeding bouts, nor the nutritional content of the breastmilk of Makushi women. Thirteen dietary surveys (3 male and 10 female) out of 736 were excluded from the study because individual values for one or more dependent variables were implausible. For example, one individual excluded from the study, an adult female, consumed 800% RDA of fat. The 13 surveys comprise a small percentage of the total number of surveys used (736), and are interpreted as valid.

The mean number of dietary surveys contributed by females and males per villages was 12.8 (± 5.6) and 24.3 (± 7.8), respectively. The characteristics of the surveyed households are shown in Table 5.2.

5.1.2 Seasonal changes in nutritional intake among age and sex groups

Overall means and standard deviations for wet and dry seasonal intakes of energy, protein, fat, and vitamin A intakes for females and males are shown in Table 5.3 and Table 5.4, respectively. Among female children, aged 1-12 years, and female adults, aged ≥ 20 years, more calories were consumed in the wet season (1242.2 ± 512.2 kcal vs. 1189.7 ± 492.6 kcal and 2008.9 ± 455.7 kcal vs. 1989.1 ± 572.5 kcal, respectively). The reverse was found true for female adolescents, aged 13-19 years, whose mean energy intake for the dry season was 2129.8 ± 1034.3 kcal, compared to 1803 ± 843.9 kcal for the wet season. Seasonal differences in energy intake among female groups were not statistically significant.

Table 5.2. Characteristics of the 24-Hour Dietary Recall Study Population in 2001-2002 in 10 Makushi villages of the North Rupununi

	Wet Season	Dry Season
Number of different households	65	68
Number of different interviewees	185	197
Number of dietary surveys	358	365
Female surveys	232	235
Male surveys	126	130
Sex groups:		
Female	117	126
Male	68	71
Age groups:		
1-12 years[1]	45%	44%
13-19 years	6%	5%
>=20 years	49%	51%
Pregnant females (>=13 years)	8%	4%
Lactating females (>=13 years)	85%	82%

[1]The youngest age group begins at one year old as breastfeeding infants were omitted from data analyses. Infants were exclusively breastfed until 5.76+2.79 months and breastfeeding ceased at 19.58+6.72 months (Milner, Bulkan, and Wilson. In preparation.)

Seasonal comparisons of nutritional intake and food variety among female groups are shown in Table 5.3. While not statistically significant, female adolescents consumed higher intakes of protein and fat during the dry season: 64.9 ± 43.9 g vs. 45.1 ± 24.6 g of protein, and 23.4 ± 18.8 g vs. 16.5 ± 14.6 g of fat. The wet season intake of vitamin A was statistically significantly greater than dry season intake among female children 4885.4 ± 2754.9 IU vs. 3025.3 ± 3262.3 IU (2-sample t-test, $P = 0.005$) and female adults 7510.5 ± 4084.5 IU vs. 1674.2 ± 2227.9 IU (2-sample t-test, $P < 0.001$). Seasonal differences in daily food intake variety were not significant.

Seasonal comparisons of nutritional intake and food variety among male groups are shown in Table 5.4. Protein and fat intakes showed no significant seasonal variation. Similar to the female groups, male children and adult groups exhibited a higher intake of vitamin A during the wet season. Wet season intakes of vitamin A were significantly greater than dry season intakes among male children 8695.1 ± 6977.3 IU vs. 2517.0 ± 2424.2 IU (2-sample t-test, $P < 0.001$) and male adults 6824.3 IU ± 7150.7 IU vs. 2324.7 ± 2151.5 IU (2-sample t-test, $P = 0.014$). Among male children food variety differed significantly by season (2-sample t-test, $P = 0.018$) with 7.6 ± 1.4 different foods consumed daily in the wet season and 6.5 ± 1.7 in the dry season.

Table 5.3 Overall energy, protein, fat, and vitamin A intake, and food variety during the wet and dry season among females.

			Season						
			Wet			Dry			
Sex	Age	Variable	Mean	(s.d)	n	Mean	(s.d)	n	P^{1}
Female	1-12 y	Energy (kcal)	1242.2	512.2	77	1189.8	492.6	80	0.173
		Protein (g)	40.5	22.8		36.9	20.3		0.308
		Fat (g)	16.0	12.5		15.0	18.1		0.879
		Vitamin A (IU)	4885.4	2754.9		3025.3	3262.3		**0.005**
		Food Variety	7.4	1.6		6.9	2.0		0.227
Female	13-19 y	Energy (kcal)	1803	843.9	16	2129.8	1034.3	18	0.240
		Protein (g)	45.1	24.6		64.9	43.9		0.116
		Fat (g)	16.5	14.6		23.4	18.8		0.291
		Vitamin A (IU)	7582.5	5848.2		4716.1	8921.2		0.613
		Food Variety	8.4	1.4		7.6	2.4		0.343
Female	≥20 y	Energy (kcal)	2008.9	455.7	141	1989.1	572.5	140	0.517
		Protein (g)	55.0	16.5		58.8	28.6		0.691
		Fat (g)	19.9	8.3		19.5	6.8		0.796
		Vitamin A (IU)	7510.5	4084.5		1674.2	2227.9		**<0.001**
		Food Variety	7.6	0.8		7.1	1.4		0.136

[1]Seasonal difference was analysed by two sample of unequal variance t-test measures: significance at P ≤ 0.05

Table 5.4 Overall energy, protein, fat, and vitamin A intake, and food variety during the wet and dry season among males.

			Season						
			Wet			Dry			
Sex	Age	Variable	Mean	(s.d)	n	Mean	(s.d)	n	P^1
Male	1-12 y	Energy (kcal)	1254.5	256.6	67	1118.6	409.5	79	0.117
		Protein (g)	37.4	14.5		32.6	15.1		0.357
		Fat (g)	13.8	12.9		14.0	8.2		0.680
		Vitamin A (IU)	8695.1	6977.3		2517.0	2424.2		**<0.001**
		Food Variety	7.6	1.4		6.5	1.7		**0.017**
Male	13-19 y	Energy (kcal)	1843.1	229.3	14	1519.6	274.5	9	0.112
		Protein (g)	42.6	11.0		46.1	3.3		0.995
		Fat (g)	12.8	11.0		11.6	4.1		0.833
		Vitamin A (IU)	6567	4236.7		1752.7	2343.9		0.176
		Food Variety	6.8	0.6		6.3	3.2		0.373
Male	≥20y	Energy (kcal)	2406.6	1041.8	44	1859.6	323.9	42	0.120
		Protein (g)	60.9	17.6		56.2	9.9		0.683
		Fat (g)	15.1	6.7		17.0	10.5		0.835
		Vitamin A (IU)	6824.3	7150.7		2324.7	2151.5		**0.014**
		Food Variety	6.8	0.9		6.5	2.0		0.824

[1]Seasonal difference was analysed by two sample of unequal variance t-test measures: significance at $P \leq 0.05$

5.1.3 Overall seasonal changes in nutritional intake

Significant seasonal differences in nutritional intake are present when the 24-hour dietary intake survey results are combined for all age and sex groups. Wet season intake of energy (2-sample t-test, $P = 0.023$), vitamin A (2-sample t-test, $P < 0.001$) and food variety (2-sample t-test, $P = 0.004$) were significant greater in the wet season (Table 5.5). Seasonal variation in fat and protein intakes was not significant.

Table 5.5 Mean wet and dry season daily nutrient intakes and food variety among the Makushi (±SD)

	Wet Season	Dry Season	*P*
Energy (kcal)	1767.5 ± 996.4	1601.5 ± 941	**0.023**
Protein (g)	49.7 ± 42	47.9 ± 37.7	0.543
Fat (g)	16.6 ± 29.6	16.1 ± 20.1	0.801
Vitamin A (IU)	7580.2 ± 10925.3	2560.5 ± 64.7	**<0.001**
Food Variety	7.5 ± 2.2	7.0 ± 2.6	**0.004**

5.1.4 Village-based seasonality in nutritional intake

Two-tailed paired t-tests of unequal variance were performed on the nutritional intake results derived from 24-hour dietary recalls to determine the specific nutrient intakes that varied significantly between seasons within each age and sex cohort (Table 5.6). Female children residing in Annai showed significantly higher values for energy intake (2-sample t-test, $P < 0.01$), protein intake (2-sample t-test, P = 0.025), vitamin A intake (2-sample t-test, $P < 0.001$) and food variety (2-sample t-test, $P < 0.0001$) during the wet season. Female children of Crashwater and Wowetta showed a significantly higher intake of energy during the wet season (2-sample t-test, $P = 0.021$, and 2-sample t-test, $P = 0.001$, respectively), while female children of Surama had significantly higher intakes of energy and protein during the dry season (2-sample t-test, $P = 0.032$ and $P = 0.044$, respectively). Female children of Fairview had a significantly higher intake of protein during the dry season (2-sample t-test, P = 0.013) and greater food variety during the wet season (2-sample t-test, $P = 0.039$). The protein intake of Wowetta female children was significantly higher during the wet season (2-sample t-test, $P = 0.009$), as was fat intake (2-sample t-test, $P = 0.009$). The variety of food types consumed by female children of Yakarinta was significantly higher during the wet season (2-sample t-test, $P = 0.005$).

Female adolescents of Fairview had significantly higher intakes of protein during the dry season (2-sample t-test, $P = 0.019$). The vitamin A intake of female adolescents in Surama was significantly higher during the wet season (2-sample t-test, $P = 0.009$), as was food variety among female adolescents of Yakarinta (2-sample t-test, $P = 0.006$), respectively.

Female adults of Massara exhibited a significantly higher dry season intake of protein and fat (2-sample t-test, $P = 0.025$ and $P = 0.019$, respectively), and adult females of Surama exhibited a significantly higher dry season intake of protein (2-sample t-test, $P = 0.025$) (Table 5.6). Vitamin A intake was found to be significantly greater in the wet season among female adults of Annai (2-sample t-test, $P = 0.008$), Fairview (2-sample t-test, $P = 0.039$), Kwataman (2-sample t-test, $P = 0.013$), Massara (2-sample t-test, $P = 0.029$), Rupertee (2-sample t-test, $P = 0.008$), and Yakarinta (2-sample t-test, $P = 0.005$). Female adults of Annai, Fairview, and Yakarinta had significantly higher food variety during the wet season (2-sample t-test, $P = 0.007$, $P = 0.003$, $P = 0.014$, respectively), and female adults of Surama showed significantly higher food variety during the dry season (2-sample t-test, $P = 0.016$). There were no significant seasonal differences in energy intake among female adult groups of the 10 Makushi villages studied.

Male children in Annai and Fairview had a significantly higher intake of vitamin A during the wet season (2-sample t-test, $P = 0.009$ and $P = 0.011$, respectively) (Table 5.6). A significantly higher variety of foods were consumed during the wet season for male children of Annai, Fairview, and Yakarinta (2-sample t-test, $P = 0.003$, $P = 0.002$, and $P = 0.039$ respectively). During the dry season, fat intake was found to be significantly higher among male children of Massara (2-sample t-test, $P = 0.011$) and Surama (2-sample t-test, $P = 0.005$).

Male adolescents of Crashwater consumed a greater variety of foods during the wet season (2-sample t-test, $P = 0.004$).

Male adults of Fairview (2 sample t-test, $P = 0.003$) consumed a greater variety of goods during the wet season, while male adults of Massara had greater food variety during the dry season (2-sample t-test, $P = 0.016$). Male adult intakes of vitamin A were significantly higher in the wet season for male adults from Fairview and Rupertee (2-sample t-test, $P = 0.041$ and $P = 0.013$, respectively).

Table 5.6 *P*-values resulting from a comparison of dry and wet season dietary intakes by male and females as recorded in 24-hour dietary recalls (two-sample unequal variance t-tests) [1]

Village	Children (1-12 years)									
	Energy (kcal)		Protein (g)		Fat (g)		Vitamin A (IU)		Food Variety	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Annai	**0.010** (W)	0.570	**0.025** (W)	0.607	0.063	0.379	**0.001** (W)	**0.009** (W)	**0.0001** (W)	**0.003** (W)
Aranaputa		0.867		0.481		0.414		0.810		0.098
Crashwater	**0.021** (W)	0.976	**0.037** (W)	0.512	0.248	0.439	0.839	0.687	0.267	0.630
Fair View	0.201	0.450	**0.013** (D)	0.221	0.698	0.381	0.267	**0.011** (W)	**0.039** (W)	**0.002** (W)
Kwataman	0.186	0.189	0.095	0.779	0.070	0.709	0.186	0.082	0.096	0.730
Massara	0.569	0.194	0.572	0.639	0.338	**0.011** (D)	0.294	0.149	0.879	0.291
Rupertee	0.477	0.236	0.823	0.152	0.850	0.214	0.374	0.058	1.000	0.322
Surama	**0.032** (D)	0.423	**0.044** (D)	0.139	0.125	**0.005** (D)	0.440	0.438	0.337	0.587
Wowetta	**0.001** (W)	0.051	**0.009** (W)	0.214	**0.032** (W)	0.726	0.866	0.347	0.949	0.802
Yakarinta	1.000	0.160	0.518	0.362	0.403	0.188	0.175	0.761	**0.005** (W)	**0.039** (W)

[1] Significant differences are highlighted with bold text. The season which had greater intake is labelled (W for wet season and D for dry season). Those cells without a probability shown lacked sufficient data for this analysis.

Table 5.6 cont. *P*-values resulting from a comparison of dry and wet season dietary intakes by male and females as recorded in 24-hour dietary recalls (two-sample unequal variance t-tests) [1]

	Adolescent (13-19 years)									
Village	Energy (kcal)		Protein (g)		Fat (g)		Vitamin A (IU)		Food Variety	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Annai										
Aranaputa										
Crashwater		0.083		0.763		0.564		0.181		**0.004 (W)**
Fair View	0.268		**0.019 (D)**		0.155		0.356		**0.032 (W)**	
Kwataman	0.343		0.780		0.428		0.362		0.421	
Massara	0.488	0.715	0.076	0.175	0.296	0.179	0.999	0.407	0.147	0.421
Rupertee										
Surama	0.238		0.363		0.135		**0.009 (W)**		0.797	
Wowetta										
Yakarinta	0.169	0.816	0.929	0.933	0.332	0.482	0.759	0.846	**0.006 (W)**	0.075

[1] Significant differences are highlighted with bold text. The season which had greater intake is labelled (W for wet season and D for dry season). Those cells without a probability shown lacked sufficient data for this analysis.

Table 5.6 cont. ***P*-values resulting from a comparison of dry and wet season dietary intakes by male and females as recorded in 24-hour dietary recalls (two-sample unequal variance t-tests)** [1]

	Adults (≥20)									
Village	Energy (kcal)		Protein (g)		Fat (g)		Vitamin A (IU)		Food Variety	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Annai	0.320		0.196		0.212		**0.008 (W)**		**0.007 (W)**	
Aranaputa	0.154	0.791	0.718	0.883	0.861	0.137	0.655	0.818	0.340	0.799
Crashwater	0.241		0.103		0.572		0.179		0.125	
Fair View	0.807	0.991	0.688	0.488	0.791	0.256	**0.039 (W)**	**0.041 (W)**	**0.004 (W)**	**0.003 (W)**
Kwataman	0.338	0.999	0.932	0.797	0.974	0.885	**0.013 (W)**	0.408	0.117	0.818
Massara	0.766	0.201	**0.025 (D)**	0.951	**0.019 (D)**	0.312	**0.029 (W)**	0.396	0.378	**0.016 (D)**
Rupertee	0.446	0.989	0.727	0.707	0.197	0.405	**0.008 (W)**	**0.013 (W)**	0.391	0.592
Surama	0.138		**0.024 (D)**		0.173		0.301		**0.017 (D)**	
Wowetta	0.693		0.856		0.379		0.273		0.362	
Yakarinta	0.276		0.950		0.141		**0.005 (W)**		**0.014 (W)**	

[1] Significant differences are highlighted with bold text. The season which had greater intake is labelled (W for wet season and D for dry season). Those cells without a probability shown lacked sufficient data for this analysis.

5.1.5 Seasonal Variation in Nutritional Adequacy

A comparison of wet and dry season nutrient intakes with RDA (National Academy of Sciences, 2003) is shown in Figure 5.1. Energy and fat intakes of the Makushi participants are consistently below RDA. For male and female age cohorts, wet season RDA of nutritional intake values tend to be higher than dry season values, although this difference is not significant.

Seasonal intakes of vitamin A are highly variable. For example, among female children the difference between wet and dry season RDA of vitamin A is 141%. Wet season vitamin A intake is significantly higher than dry season vitamin A intake among male and female children (2-sample t-test, $P < 0.001$ and $P = 0.006$, respectively) and male and female adult groups (2-sample t-test, $P = 0.014$ and $P < 0.001$, respectively).

Figure 5.1 Comparison of wet and dry season mean RDA for nutrient intakes among female and males by age group

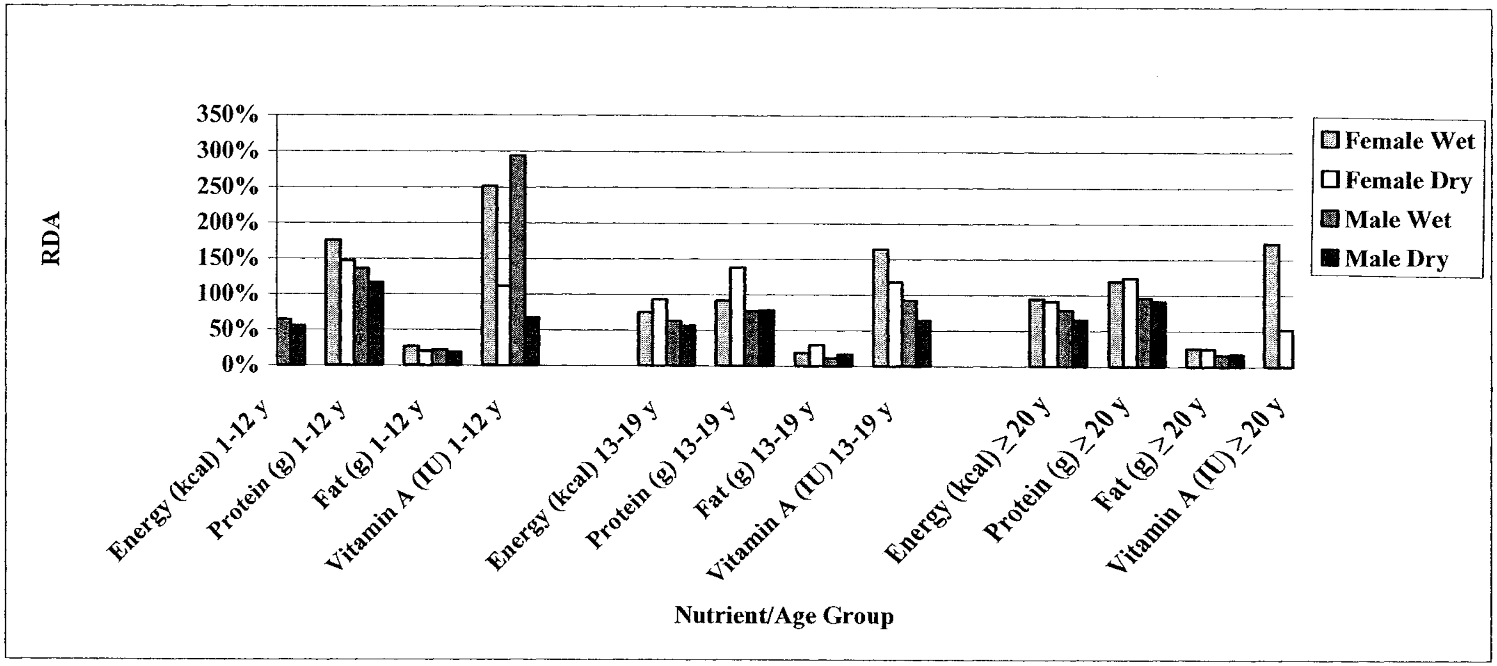


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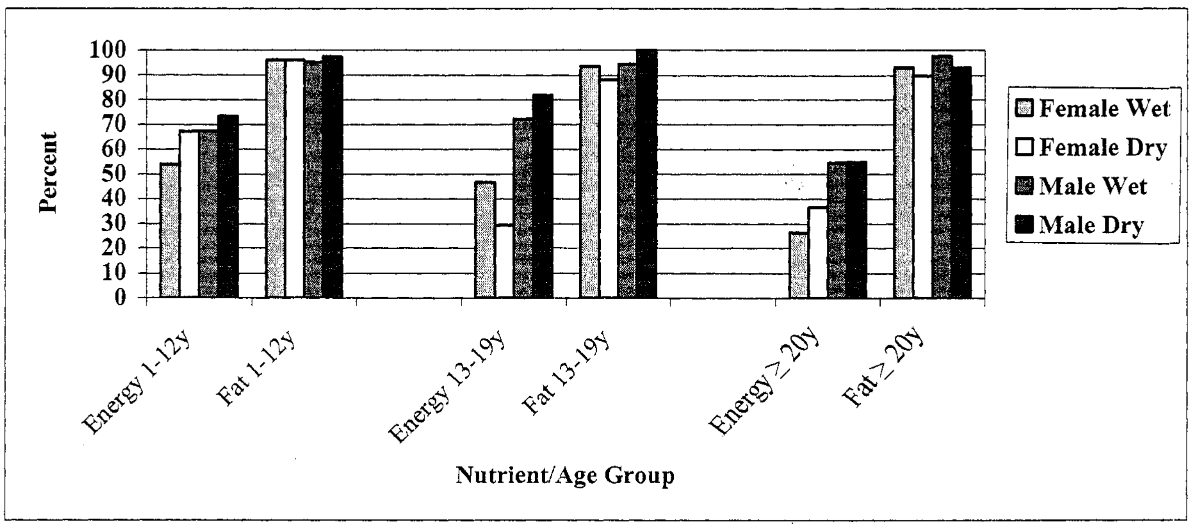
Figure 5.2 illustrates the large percentage of individuals represented by 24-hour dietary intake surveys who consumed less than 67% RDA of energy and fat for their respective age and sex. Generally, age and sex groups recorded greater percentages of inadequate energy intake during the dry season, excepting female adolescents. Inadequate fat intake was highly prevalent among all age and sex groups. In the dry season fat intake was insufficient among 100% of male adolescents. Given the large percentages of nutritional inadequacy found in the wet and dry seasons, in no instance was the seasonal difference significant.

Figure 5.2 Percentage of females and males with energy and fat intake less than 67% RDA



5.2 Food Type Intake

Data indicating the overall seasonal contribution of each food type to the daily energy intake and the seasonal prevalence of food types in the 24-hour dietary recall surveys are presented in Figure 5.3 and Table 5.7. Percent contributions of food types to daily energy intake were compared with the prevalence of food types recorded in the 24-

hour dietary recall surveys. A comparison of seasonal contributions of food types to daily energy intake among females are shown in Table 5.8, and among males in Table 5.9.

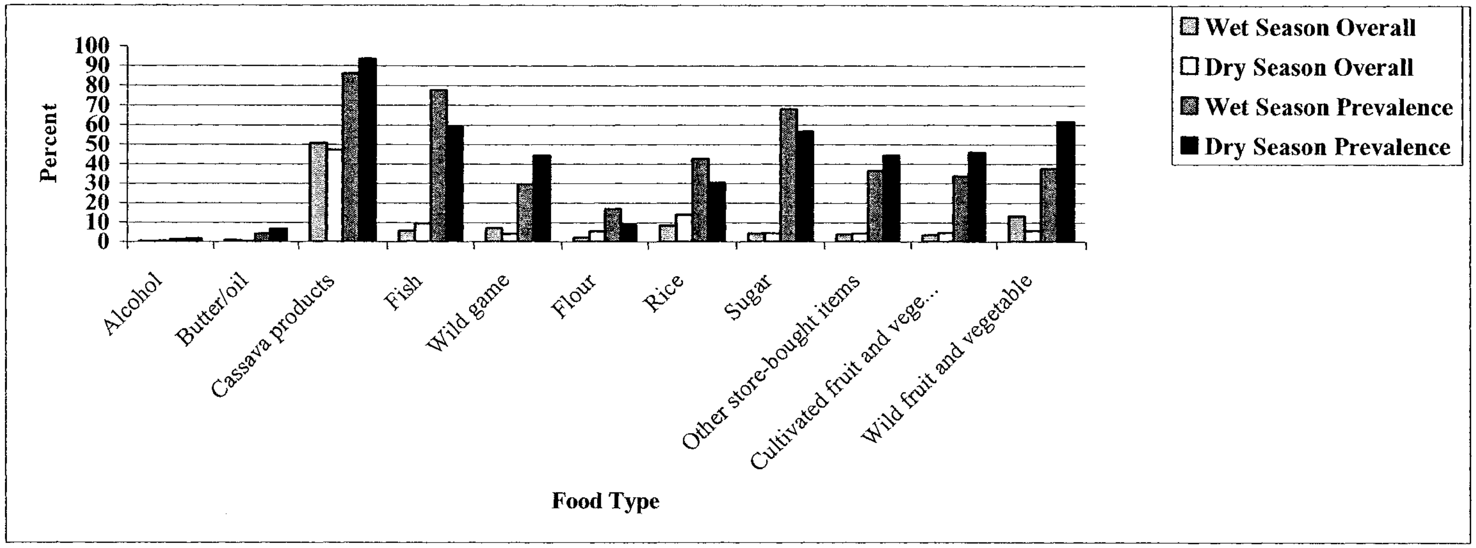
5.2.1 Food Type Prevalence

The prevalence of food types recorded during the wet and dry season in the 24-hour dietary recalls was compared. Prevalence refers to the number of times a food group, or a food item within a food group, has been recorded (consumed) out of the total number of 24-hour dietary recall surveys for a given season. The food types include alcohol, butter/oil, manioc products, consisting of *parakari*, *farine*, manioc bread, and *sipe*, fish, wild game, flour, rice, sugar, other store-bought items, cultivated fruit and vegetable, and wild fruit and vegetable. A comparison of all dry season foods and wet season foods consumed in the 10 villages combined indicated a significant difference in the number of times food types were consumed during the wet and dry season (chi square 71.46, df = 10, $P < 0.001$), indicating that the Makushi have a significantly different seasonal repertoire of food.

Manioc products, including fermented manioc beverages, were recorded in 93.6% and 86% of the 24-hour dietary recall surveys during the wet and dry season, respectively. The prevalence of fish was 77.5% in the dry season, but dropped to 59.2% in the wet season, whereas game was recorded in 29.6% of dry season surveys and 44.4% of wet season surveys. Wild fruits and vegetables were consumed more often in the wet season (61.7%) than in the dry season (37.5%), while the opposite was found for cultivated fruits and vegetables (45.8% in the dry season and 33.7% in the wet season).

Flour, usually consumed in the form of 'bake', a Makushi quick-bread, or flour porridge, was almost twice as common during the dry season (16.8%) compared to the wet season (8.9%). Sugar, frequently added to hot beverages and porridge, was recorded more often in dry season surveys (67.9 % vs. 56.7%), as was rice (42.7% vs. 30.4%). The consumption of alcohol, butter and oil, and miscellaneous store-bought items, such as candy and pasta, did not differ from season to season. Statistical analyses comparing the wet season versus dry season frequencies of recorded individual food types were not computed.

Figure 5.3 Overall percent contribution of food types to daily energy intake (on days when consumed) and food type prevalence[1]



[1]Prevalence refers to the number of times a food group, or a food item within a food group, was recorded out of the total number of 24-hour dietary recall surveys for a given season.

Table 5.7 Overall seasonal differences in food type contribution to daily energy intake

Food type	Wet	Dry	P^1
Alcohol	0.3%	0.3%	0.858
Butter/oil	0.8%	0.4%	0.073
Manioc products	50.6%	47.2%	0.121
Fish	5.7%	9.5%	**< 0.001**
Wild game	7.1%	4.2%	**< 0.001**
Flour	2.1%	5.4%	**< 0.001**
Rice	8.4%	14.0%	**< 0.001**
Sugar	4.3%	4.5%	0.813
Other store-bought items	3.8%	4.3%	0.532
Cultivated fruit and vegetable	3.5%	4.7%	0.090
Wild fruit and vegetable	13.3%	5.6%	**< 0.001**

NB. (computer glitch) Pagination is fixed ... read as normal

[1]Seasonal variation was analysed by two-sample of unequal variance t-test measures: significance at $P \leq 0.05$

5.2.2 Food Type Contribution to Energy Intake

Considering the total study population, five of 11 food type contributions to daily energy intake differed significantly between seasons (Table 5.7). Fish contributed more to daily energy intake during the dry season (2-sample t-test, $P < 0.001$). Flour and rice were also more energetically important during the dry season (2-sample t-test, $P < 0.001$), as was rice (2-sample t-test, $P < 0.001$). Both of these foods are store-bought. Wild game and wild fruits and vegetables provided a greater amount of energy to the Makushi diet in the wet season (2-sample t-test, both $P < 0.001$). Alcohol, butter and oil, manioc products, sugar, other store bought items, and cultivated fruits and vegetables did not vary in their seasonal energetic contributions.

Significant seasonal variation for some of the food types were found among age and sex groups (Tables 5.9 and 5.10). Manioc products contributed significantly more to the energy intake of male adults in the wet season (2-sample t-test, $P = 0.042$). The contribution of fish to daily energy intake was significantly higher in the dry season among female children (2-sample t-test, $P = 0.021$), female adolescents (2 sample t-test, $P = 0.004$), female adults (2 sample t-test, $P < 0.001$), and male children (2-sample t-test, $P = 0.013$). Wet season consumption of game was significantly higher among female children (2 sample t-test, $P = 0.039$) and female adults (2-sample t-test, $P = 0.003$). Flour intake was significantly higher during the dry season among female children (2 sample t-test, $P = 0.008$), contributing 6.9% of daily energy intake in the dry season and 1.6% in the wet season, and flour intake was higher among male adults during the dry season (9.0% vs. 1.0% in the wet season) (2-sample t-test, $P = 0.014$). During the dry season, male adults consumed significantly more rice than during the wet season (2-sample t-test, $P = 0.010$). The contribution of wild fruits and vegetables to wet season energy intakes was significantly higher among female adults (2-sample t-test, $P < 0.001$), male children (2-sample t-test, $P < 0.001$), male adolescents (2-sample t-test, $P = 0.046$) and male adults (2-sample t-test, $P = 0.009$).

Seasonal variation in the energetic contributions of alcohol, butter and oil products, sugar, miscellaneous store-bought items, and cultivated fruits and vegetables was not found to be significant among the sex and age cohorts participating in this study. The contribution of manioc products to the daily energy intakes of female age cohorts did not differ between seasons. The energetic contribution of wild fruits and vegetables was similar in the wet and dry season for female children and adolescents. The seasonal energetic contribution of flour and rice did not vary for male children and adults.

Table 5.8 Percent contributions of food types to daily energy intake of females

	Female								
	Wet	Dry	P [1]	Wet	Dry	P	Wet	Dry	P
Food type	1-12y			13-19			≥20		
n	78	82		15	15		141	138	
Alcohol	0.0%	0.0%		0.0%	0.0%		0.0%	0.4%	
Butter/oil	0.7%	0.0%		0.0%	1.4%		0.9%	0.4%	
Manioc products	46.7%	42.3%		52.4%	48.9%		55.0%	53.5%	
Fish	5.1%	7.8%	*	6.0%	12.2%	**	5.7%	9.6%	**
Wild game	10.2%	6.1%	*	4.1%	1.8%		6.7%	3.4%	**
Flour	1.6%	6.9%	**	1.2%	3.4%		2.1%	4.0%	
Rice	8.1%	11.8%		5.5%	18.7%		8.5%	13.3%	
Sugar	5.5%	4.8%		7.6%	4.2%		3.5%	2.9%	
Other store-bought items	4.5%	5.5%		6.5%	0.7%		2.6%	4.4%	
Cultivated fruit and vegetable	3.3%	4.9%		1.6%	1.2%		3.9%	4.5%	
Wild fruit and vegetable	14.2%	9.8%		15.0%	7.4%		11.1%	3.6%	**

[1] Seasonal variation was analysed with two sample of unequal variance t-test,
$*P \leq 0.05$, $**P \leq 0.01$

Table 5.9 Percent contributions of food types to daily energy intakes of males

	Male								
	Wet	Dry	P [1]	Wet	Dry	P	Wet	Dry	P
Food type	1-12y			13-19			≥20		
n	69	78		12	10		43	42	
Alcohol	0.3%	0.0%		0.0%	0.0%		1.1%	1.4%	
Butter/oil	0.8%	0.5%		0.0%	0.0%		0.9%	0.0%	
Cassava products	42.0%	47.5%		70.2%	75.5%		54.2%	39.5%	*
Fish	5.5%	8.9%	*	7.4%	13.0%		7.0%	9.5%	
Wild game	5.9%	3.8%		5.3%	2.7%		6.6%	2.0%	
Flour	4.1%	6.4%		0.0%	0.0%		1.0%	9.0%	*
Rice	8.2%	10.1%		1.7%	4.2%		7.7%	23.0%	**
Sugar	4.8%	6.4%		2.6%	3.6%		4.0%	4.2%	
Other store-bought items	5.2%	5.5%		1.0%	0.0%		4.7%	3.3%	
Cultivated fruit and vegetable	3.3%	4.6%		2.6%	0.0%		3.5%	5.9%	
Wild fruit and vegetable	17.4%	6.3%	**	9.3%	1.0%	*	9.4%	2.3%	**

[1] Seasonal variation was analysed with two sample of unequal variance t-test,
$*P \leq 0.05$, $**P \leq 0.01$

5.3 Semi-Structured Interviews

5.3.1 Study Population

The semi-structured interview study population comprised 40 females and one male. The mean number of participants per village numbered 4.1 ± 3.3. The mean age of the participants was 36.6 ± 9.9 years with a range of 21-54 years. The mean number of children per participant was 6.4 ± 3.2, with a mean age of 9.1 ± 6.2 years and range of 0-28 years.

5.3.2 Wet and Dry Season Foods

Table 5.10 shows a comparison of the two methods of data collection employed in this study by presenting the 15 most frequently consumed food items particular to each season derived from the 24-hour dietary recall surveys and semi-structured interviews. The food listed under the 'Wet Season' and 'Dry Season' columns for the 24-hour dietary recalls contain each different food item recorded during that particular season. As several food items are consumed during throughout the year, for example manioc bread and sugar, these foods will be reported in the 'Wet Season' and 'Dry Season' columns, and again in the 'combined' column. The 'combined' column represents the most frequently recorded food items in the 24-hour dietary recalls when both seasons were pooled. The 'both seasons' column represents the answers of the interviewees when they were asked specifically about foods consumed during both seasons. Therefore, the 'combined' column and the 'both seasons' column are comparable as they show foods consumed throughout the year.

During the wet season 204 different food items were recorded in the 24-hour dietary recall surveys and 128 in the semi-structured interviews. The 24-hour dietary recall surveys included 197 different dry season food items and the semi-structured interviews included 126. Further interpretations of the frequency of food item consumption among the 24-hour dietary recalls are illustrated in Figure 5.3.

Farine, sugar, manioc bread, and salt were the most frequently consumed food items in the wet and dry season, according to the 24-hour dietary recalls. Mango and powdered milk, both important food items, ranked higher in the wet season. *Casareep* and fish broth, two ingredients chiefly associated with the main Makushi dish called *tuma*, are ranked higher in the wet season. Meat from domestic or wild resources did not rank among the top 15 regularly recorded foods consumed during the wet season.

The principal foods that the interviewees associated with the wet season included three game types, deer, tapir and agouti as well as six domesticated plant foods and three fish. The 15 most commonly mentioned dry season foods included seven fishes, four wild fruits, three game types, and one domesticated vegetable. Those foods identified as foods consumed throughout the year included manioc products, plant-based teas, milk, and sugar.

Table 5.10 Food items consumed in the wet and dry seasons: a comparison of the number of times items were mentioned in the 24-hour dietary recalls and semi-structured interviews

	24-Hour Dietary Recall			Interviews		
Rank	Wet Season	Dry Season	Combined	Wet Season	Dry Season	Both Seasons
1	farine: 358[1]	farine: 416	farine: 1574	pumpkin: 8	fish:: 10	farine: 8
2	sugar: 288	sugar: 411	sugar: 1335	agouti: 6	lukunani: 8	casareep: 8
3	mango: 184	salt: 158	manioc bread: 614	mango: 6	perai: 8	tuma: 8
4	manioc bread: 139	manioc bread: 146	mango: 508	watermelon: 6	meat:: 7	manioc bread: 7
5	salt: 108	sipe: 141	sipe: 477	corn: 6	agouti: 6	sweet manioc: 6
6	sipe: 106	rice porridge: 100	salt: 465	meat:: 6	patwa: 6	lemon grass tea: 5
7	powdered milk: 101	rice: 98	powdered milk: 392	fish:: 5	jamoon: 6	tapioca: 5
8	casareep: 68	mango: 84	rice: 372	labba: 5	tapir: 6	pepper pot: 4
9	perai: 63	casareep: 80	rice porridge: 310	deer: 5	houri: 6	cassiri: 4
10	rice: 63	powdered milk: 76	casareep: 263	kokerite: 5	lu: 5	orange leaf tea: 3
11	rice porridge: 61	houri: 75	banana: 216	dare: 4	hassar: 5	sugarcane: 2
12	farine porridge: 51	beef: 74	orange: 216	bora: 4	kassi: 5	cow milk: 2
13	fish broth: 51	fried bake: 71	fried bake: 209	serebe: 4	yam: 5	curry: 1
14	orange: 49	flour porridge: 69	fish broth: 201	cashew: 3	mango: 4	plantain: 1
15	starch porridge: 45	fish broth: 62	parakari: 199	tomatoe: 3	whitty: 4	rice porridge: 1
Total # different foods	204	197	366	128	126	48

[1] The number after each food item indicates how many times the food item was recorded in the specified seasonal range

The following paragraphs will summarise the results. The comparisons of the overall energy, protein, fat, and vitamin A, and food variety among females and males revealed significantly greater intakes of vitamin A intake among female children and adults and male children and adults (Tables 5.3 and 5.4). Energy, protein, and fat intakes did not vary seasonally, but food variety was greater in the wet season for male children. Considering the entire study population, intakes of energy and vitamin A, and food variety were greater in the wet season (Table 5.5).

Village-based analyses of seasonal variation in nutritional intake and food variety show two general trends (Table 5.6). First, female children of Annai, Crashwater, and Wowetta showed greater intakes of energy and protein in the wet season, while female children of Fairview and Surama exhibited greater intakes of energy and protein in the dry season. Second, female adults in six of ten villages had greater intakes of vitamin A in the wet season and female adults in Annai, Fairview, and Yakarinta had greater food variety in the wet season. Males did not demonstrate significant trends.

A comparison of the wet and dry season nutrient intakes among the Makushi with RDA revealed that a large percentage of the study participants are consistently consuming less than 67% RDA. As shown in Figure 5.2, inadequate energy and fat intake was highly prevalent among all age and sex groups.

The energetic contributions of five of 11 food types varied seasonally. Fish, flour, rice, and cultivated fruits and vegetables contributed more to energy intakes during the dry season, and wild fruits and vegetables contributed more energy to the Makushi diets in the wet season (Figure 5.3 and Table 5.7). All female age groups consumed significantly more fish in the dry season, while male groups indicated a greater wet season dependence on wild foods (Tables 5.9 and 5.10).

A comparison of the 24-hour dietary recalls and the interview responses illustrated the importance of manioc products in the Makushi diet. The 24-hour dietary recalls showed that *farine*, sugar, and manioc bread are frequently consumed in the wet and dry seasons, with fish and meat raking higher in the dry and wet season, respectively. The interview responses showed that fish and wild fruits are associated with the dry season foods, and that game and domesticated plant foods are associated with the wet season (Figure5.10).

CHAPTER SIX: DISCUSSION

The purpose of this research is to understand the impact of seasonality on the nutritional intake of Makushi Amerindians of Guyana. The first hypothesis proposed that seasonal cycles influence patterns of nutritional intake. The second hypothesis submitted that Makushi people of different age and sex cohorts will be affected in different manners to seasonal changes in nutritional intake. The methods employed to examine the nutritional intake of the Makushi included 24-hour dietary recall surveys and semi-structured interviews with Makushi participants.

The results of statistical analyses of 24-hour dietary recalls uncovered several seasonal differences in nutritional intake. In combined villages, female children and adults, and male children and adults had significantly greater vitamin A intake during the wet season. Nutritional intake amounts of energy, protein, and fat were not seasonally different. In individual villages, female children exhibited seasonal differences in energy and fat intake without a clear seasonal pattern, and female adults had greater wet season intakes of vitamin A. However, there was no general seasonal trend in nutritional intake or food variety among age and sex cohorts in the individual villages. Two general conclusions are drawn from the results. First, the small number of significant seasonal differences does not indicate that seasonality influences nutritional intake of all Makushi. Second, different age and sex cohorts are affected differently by seasonal changes in nutritional intake.

6.1 Nutritional Adequacy among the Makushi

For the two months of dietary intake considered here, the Makushi diets are nutritionally insufficient. Intake amounts of energy and fat were less than 67% RDA for all cohorts examined in the present study, suggesting that a large percentage of individuals were suffering from energy or fat undernutrition (Johnson et al., 1974, Kucera and McIntosh, 1991; Omori and Greksa, 2002). Fat intake did not differ significantly between seasons, and approximately 88% to 100% of the total study population consumed less than 67% RDA of fat. Intakes of energy, protein, fat and vitamin A as percentages of RDA were slightly higher during the wet season, but only wet season vitamin A intake was significantly greater.

Based on mean total energy intakes of the Makushi, the wet season diet fat intake is 8.5% of total energy intake and the dry season fat intake is 9.0% of total energy intake. The minimal standards of fat intake are 15% of the total energy intake for adults, and between 30-40% for children (FAO/WHO/UNU, 1993). A diet in which fat intake is less than 15% of the total energy intake is considered not concentrated enough for young children (Wheeler, 1980). The percent contribution of fat in the Makushi diet (8.5-9.0%) and fat in child age group diet (11.9%) may make it difficult for growing children to consume adequate amounts of food to satisfy nutritional and developmental requirements.

The nutritional density of food resources consumed and intake amounts of micronutrients may provide part of the explanation for the nutritional inadequacy among the Makushi. The low and inadequate energy intake of children (approximate intakes are

72% RDA for female wet season, 62% RDA for female dry season, 64% RDA for males wet season, and 55% RDA for males dry season) may not be simply due to the quantity of food available, but to the high bulk and low nutrient density of the children's diets. Likewise, Berti, Leonard, and Berti (1997) report that the inadequate diets resulting in malnutrition among children in rural highland Ecuador may be resulting from high intake of potatoes, the most satiating food found in their study, which makes children physically incapable of eating sufficient quantities of nutritionally dense foods, generating a diet inadequate in energy, protein, and micronutrients. The high bulk, low nutrient density of children's diets is consistent with Dufour's (1992) characterisation of the diet of the Tukanoans in northwestern Amazonia. The Makushi, like the Tukanoan, dependence on the staple crop, manioc, may be producing the same results, but further investigation of micronutrient intake is required.

Anthropometric data support the proposition that the Makushi diet is inadequate for the months studied during both the wet and dry season. Wilson and Bulkan (2004) report that Makushi children are shorter than their North American equivalents. Overall, 42% of females and 37% of males were classified as stunted. On the basis of weight-for-height (WH), the prevalence of wasting in the 2-12 years age group was 9% for females and 18% for males. No individual over the age of 12 years was wasted.

As noted in Chapter Two, stunting is suggestive of long-term nutritional inadequacy, and/or unfavourable environmental conditions, particularly ones in which chronic disease and infection are common, and wasting is indicative of acute nutritional inadequacy. It is generally recognised that stunting most frequently occurs during infancy and early childhood (Keller, 1988). The anthropometric data likely reflect dietary quality and a possible relationship between nutritional inadequacy, environmental stressors, such as water quality and hygiene, and illnesses of the Rupununi region, such as endemic malaria and gastrointestinal parasites (Adam Nash, personal communication 2003; Miriam Abbot, personal communication 2004). Disease can exacerbate growth deficits and compromise nutritional status (Dufour, 1992). Studies of Amerindian groups have reported that high percentages of stunting may be indicative of infectious disease combined with long-term nutritional deficits (Orr, Dufour, and Patton, 2001; Wilson and Bulkan, 2004). A comparison of nutritional and anthropometric data illustrates the inadequacy of the Makushi diet and how it may be compromising the growth and development of Makushi children.

6.2 Seasonal Changes in Nutritional Intake

Generally, nutritional intakes of the macronutrients energy, protein, and fat do not differ significantly by season and do not support the proposition that seasonal patterns influence the macronutrient intake of the Makushi. While there are a few seasonal differences in vitamin A and food variety for some age and sex cohorts, and some significant differences in dietary intake when individual villages are considered, the Makushi do not appear to experience a hunger season. Rather, the Makushi seem to experience persistent food shortages.

In comparison to other indigenous populations of the lowland tropics, the Makushi diet seems to provide less, regarding energy and protein. The mean daily wet and dry season energy intakes of Tukanoan female adults are approximately 400 kcal higher than those of Makushi female adults, and mean daily protein intakes of Tukanoan female adults are 15 to 20 g higher than those of Makushi female adults (Dufour, 1992). Although seasonal comparisons are not available, mean energy intake (1794 kcal) of the Yanomami, as reported by Lizot (1993, see Chapter Two), is close to that of the Makushi, whereas the mean protein intake of the Yanomami exceeds that of the Makushi by more than 20 g. Hurtado and Hill (1990) report that the Hiwi mean wet season energy intake is 2053 kcal and 1591.5 kcal in the dry season, with daily energy intakes rising to almost 3000 kcal in the late wet season and dropping to around 1300 kcal in the early wet season. The mean seasonal figures are comparable to those of the Makushi. Interestingly, the differences in daily energy intake throughout the year may describe a phenomenon also present among the Makushi. Only analysis of 24-hour dietary recalls for all months of the year would be able to confirm this suggestion.

Variation was documented for macronutrients and vitamin A, some of which were significantly different in the wet and dry season. Considering all villages combined, vitamin A intake was higher in the wet season for female and male children and female and male adult cohorts, and dietary variety was significantly higher for male children in the wet season.

The seasonal difference in vitamin A intake may be attributed to the fruiting schedule of the mango tree. Mangoes, with 3894 International Units (IU) of vitamin A per 100 g, constitute an important source of this micronutrient in the Makushi diet. In most villages, mangoes ripen during the long, wet season, April through September, or, as noted in Massara, during the short, wet season in December and January. In addition, although recorded only four times in the 24-hour recalls, cow liver, an excellent source of vitamin A (35105 IU per 100g), is consumed predominantly during the wet season. Vitamin A intake below the RDA during the dry season may be problematic for children as stores can become depleting within a few months in the absence of vitamin A containing foods (Whitney and Rolfes, 2002).

The large standard deviations in vitamin A intake may be indicative of a preference for mangoes among female and male children and adults. On occasion, in April 2003, children were noted continually eating mangoes outside of meal time while playing with siblings. Mangoes are easily accessible, and may be consumed to cure boredom, to satiate hunger, or simply because they are favoured. The 24-hour dietary recalls reported days when the only food type consumed was mango.

Considering individual villages, energy and protein intake was significantly higher in the wet season for female children in Annai, Crashwater, and Wowetta. Energy and protein intake was higher in the dry season for female children of Surama, and female children of Fair View reported higher protein intake in the dry season. The higher dry season intakes of energy and protein for female children in Surama and higher protein intakes for female children in Fair View may be attributed to the geographical location of these villages, which are located in the southern periphery of the Iwokrama forest, where an abundance of wild fruits may supplement the diet. In addition, several families of Surama have large farms with an unusual and extensive list of cultivated fruits and vegetables, which they sell to other village members. These factors could increase seasonal food variety.

Additionally, seasonal consumption of vitamin A intake and food variety among female and male adults was different. Female adults in six of the ten villages examined and male adults in two of five villages for which data were available had greater wet season intakes of vitamin A. As noted above, mangoes and cow liver, excellent sources of vitamin A, are available and principally consumed in the wet season. These data may be reflecting the strong influence of seasonal patterns on food resource availability and nutritional intake. Considering seasonal differences in food variety, female adults from three villages and male adults from one village exhibited higher food variety in the wet season. The wet season is associated with the fruiting of wild food resources. Access to a greater variety of wild foods in the wet season may help to supplement the diet (Wilson and Bulkan, 2004), while increasing the diversity of foods in the Makushi diet. However, for male adults in Massara and female adults in Surama, food variety is greater in the dry season. As mentioned above, there are a number of large, well-kept farms in Surama that provide a wide selection of cultivated foods throughout the year, which may provide high dietary diversity in the dry season. Massara, on the other hand, is a savannah-riverine village located approximately 25 km from family farms and lacks a year-round link to the Georgetown-Lethem road. This isolation may affect the quantity and variety of foods that reach Massara for sale in village shops, especially in the wet season when all land transport may be halted due to flooding, resulting in a decreased availability of store-bought foods.

In light of these observations, it is important to note that, while we do not find significant seasonal differences in macronutrient intake for the combined villages, for the two months considered here, the Makushi diets are nutritionally insufficient and may be further compromised by non-statistically significant influences of seasonality on food availability. Such slight changes may constitute the proverbial "straw that broke the camel's back" among the already nutritionally stressed Makushi, pushing them over the edge to chronic nutritional stress. The Makushi have a small dietary variety, which, if reduced, may further compromise their diet, growth and development. Furthermore, and not apparent in the data collected for this study, El Niño events compromise Makushi horticultural production on a regular basis, on average every six to ten years (Iwokrama, 2003), dramatically reducing manioc yields and exacerbating dietary inadequacy.

Although the dietary intake is insufficient for the two months considered here, the lack of significant seasonal differences in dietary intake may be seen as an adaptation by the Makushi to the limitations of their environment. The Makushi follow a calendar of subsistence activities that takes advantage of the food resources available throughout the year. As noted in Chapter Three, fish is an important dietary component in the dry season, as fishing is most productive when water levels are low and calm. During the wet season, hunting game and collecting ripened wild forest fruits and vegetables predominate, with fishing trips occurring less often. Not surprisingly then, considering combined villages, fish contributed significantly more to dry season energy intakes than wet season energy intakes. A general trend was found among female and male age cohorts, whereby fish contributed more to energy intake in the dry season. For all female age cohorts and male children this seasonal difference was significant. Considering combined villages, variation in the energetic contribution of game was not seasonally significant. However, for female children and adults, the wet season contribution of game was significantly greater than that of the dry season.

Notably, manioc, the staple crop of the Makushi, is aseasonal. As noted in Chapter Three manioc production, harvesting, and processing occur year-round, allowing for a continual supply of products, such as manioc bread, *casareep*, *farine*, *tapioca*, and *parakari*. Manioc is frequently consumed. It was recorded in 93.6% of the wet season 24-hour dietary recall surveys and in 85.8% of dry season recalls. Overall, manioc provided the Makushi with 54.2% of their total energy intake in the wet season and 54.9% in the dry season. Considering combined villages, the seasonal difference in the dietary contribution of manioc was not significant. Taking into account age and sex cohorts, a general trend was found regarding greater dependence on manioc for energy in the dry season. Manioc made a significantly greater energetic contribution to the dry season diets of male adults (55.3% in the dry season vs. 54.2% in the wet season). The increased contribution of manioc to energy intake during the dry season could be the result of fewer supplementary food resources and decreased food variety in the dry season, as noted above.

Additionally, the Makushi have developed several ways to lengthen and store food supplies. *Farine* and *tapioca* can keep for months in dry conditions. Fish, game, and beef are also preserved through smoking and drying. Finally, while the vast majority of households own no animals, each village has a number of domesticated animals such as cows, donkeys, sheep, chickens, and pigs that are slaughtered on occasion. For example, cows are slaughtered in Surama at Christmas to provide a large feast for the entire village. Likewise, neighbours in some villages share food resources in times of need. Therefore, the maturation schedule of manioc, coupled with ecological and cultural characteristics of Makushi food management, may ensure a generally continual albeit small supply of food throughout the year.

6.3 Seasonal Changes in Nutritional Intake among Age and Sex Cohorts

Seasonally significant variations in nutritional intake and in percent contributions of food types to daily energy intake were documented. Energy and protein intake was greater in the wet season for female children of Annai, Crashwater, and Wowetta, and greater in the dry season for female children of Surama. Seasonal variation in energy and protein intake for male children was not found in any of the ten villages studied. Six of ten female adult cohorts, those from Annai, Fair View, Kwataman, Massara, Rupertee, and Yakarinta, exhibited significantly higher intakes of vitamin A in the wet season. Female adults, female children, and male children in Annai, Fair View and Yakarinta had greater food variety in the wet season than they did in the dry season, whereas adult females of Surama had greater food variety in the dry season than they did in the wet season. This degree of seasonal variation in vitamin A or food variety was not found among female adolescents or among male adolescent and male adult cohorts.

Considering the contributions of food types to energy intake, fish provided significantly more energy to the dry season diet of females of all age cohorts, and game was energetically more important in wet season diet of female children and female adults. Wild fruits and vegetables provided more energy to the wet season diet of males of all age cohorts, while flour and rice were energetically more important to the dry season diets of male adults.

These seasonal variations in nutritional intake, food variety, and food type consumption are based on age and sex cohorts, which support the second hypothesis that different age and sex will be affected in different manners by changes in seasonal food availability. Various activity and behavioural patterns associated with different age and sex cohorts may reveal why this hypothesis is supported.

Activity and behavioural patterns of Makushi males and females are generally determined by subsistence strategies and household chores, which are often dissimilar. Sex-determined activity patterns may determine when and what type of food is available for consumption. For example, interviewees stated that hunting and fishing is largely carried out by males and may require anywhere from two hours to two days, an observation that agrees with that of Forte (1996). In addition, interviewees noted that females are responsible for child-rearing, domestic chores, food preparation, and farm weeding and harvesting, consistent with observations by Forte (1996) and Elias, Rival, and McKey (2000). These activities are carried out around the home and on the farm. In villages where farms are located 15 to 25 km distant, families will often spend two days to two weeks at a time at the farm (Forte, 1996). During this time, family nourishment primarily consists of farm products and the gathering of wild foods.

The amount of time that a female adult spends preparing and maintaining the farm could have some bearing on household and, especially, child nutrition (Schofield, 1974; Messer, 1989). Time spent in the farm decreases time spent at home processing manioc, cooking, food gathering, cleaning, collecting fuel and water, and feeding children, for example (Schofield, 1974). Schofield (1974) reports that nutrition, especially among children, is compromised when seasonal food shortages coincide with increased labour demands of adult females. Generally, Makushi women are most active in the late dry season, during the months of April and May, as they are working to prepare their farms for planting after the first rains (Wilson, personal communication). Marginal differences in the allocation and use of female adult time may ultimately affect household nutritional intake and variation among the Makushi in ways not yet fully appreciated. These differences in male and female activity patterns may be resulting in the seasonal variation in nutritional intake found among different age and sex cohorts.

In addition to activity patterns, food supply and food variety may influence the seasonality of dietary intake. The wet season is generally associated with greater food supply and variety, as noted above. The greater wet season energy and protein intake of female children in Annai, Crashwater, and Wowetta may be due to the increased availability of cultivated and wild food resources found in and around households and farms. The wet season is characterised by increased intake of game, which, generally contains more calories than fish. Additionally, nuts, such as peanuts and cashews, are consumed during the wet season and they are high in calories and protein (USDA, 2002). Similarly, the prevalence of greater vitamin A intake and higher food variety among several cohorts in the wet season may be the result of the maturation of numerous cultivated and wild food resources. The fact that female children in Surama exhibited greater energy and protein intake in the dry season and female adults of Surama had greater food variety in the dry season is not clear. Surama has two large, well-managed, and highly productive farms within 5 km distance of the village, the products of which are sold to village inhabitants. Although an increased availability of cultivated food resources could positively influence the diet among female adults and female children in Surama, other factors such as food preference, household distribution of food, storage facilities, and infection rates should be considered.

Food preferences may be influencing the amount of food, what type of food is being consumed. The occurrence of greater food variety and higher vitamin A intake in the wet season may not be only due to a greater availability of food items, especially wild fruits, including mangoes, as it is not surprising the consumption increases with a seasonal abundance of particular food resources. Rather, the Makushi may be indicating preferences for seasonally available foods. For example, the wet season may be reintroducing food types preferred by female adults, which are not available in the dry season.

As discussed above, the food management strategies utilised by the Makushi may ensure a continual food supply throughout the year. Preferences for seasonally available food resources may halt the continued consumption of plentiful foods. Therefore, although Makushi food management strategies provide year-round food resources, they may not be equated with continual consumption of those foods. Clarification regarding whether food intake is a product of abundance or preference will require further questioning of the Makushi.

The intrahousehold allocation of food resources may account for the significant seasonal variation in the diet of female adults and female children. While numerous patterns of food distribution within the household have been documented (see Berti, Leonard, and Berti, 1997), seasonal food distribution favouring females may account for the significantly greater nutritional intakes recorded in the wet season among the Makushi. While the data suggest that inequitable distribution may be part of the explanation for differences between males and females in dietary intake, the present study lacks data which would enable us to explore this in more depth.

An additional variable which may influence dietary intake is the ecotone in which villages are located (Wilson and Bulkan 2004). As noted in Chapter Three, the villages considered in this study are situated in four different ecotones. For example, children of Annai, a savannah village, have significantly greater wet season intakes of energy, protein, and vitamin A, and food variety. Annai is located 18 km from the forest and farms, therefore lacking the availability of supplementary gathered foods that may alleviate dry season shortages of food supply and variety. Dufour (1992) proposes that variation in food supply is less problematic in rainforest regions than in the savannah because farm products and wild food resources can be harvested throughout the year. Village ecotone, however, does not explain why children of Fair View, who live in a forest-riverine village where farms are located next to homes and there are plenty of fruiting trees year-round, have seasonally variable diets. Comparing the dietary intake of individuals residing in villages located in different ecotones is biologically meaningful it has the potential to enhance our knowledge of the evolution of biological adaptations, within one cultural population, to different ecological surroundings.

Geographical isolation may be an additional factor influencing nutritional intake and variety among age and sex cohorts. Energy and protein intakes for female children of Crashwater, and vitamin A intakes and food variety for female adults of Massara and Yakarinta, are all significantly higher during the wet season. These isolated villages are located on the Rupununi River and are the furthest from the main Georgetown-Lethem road, and possibly days from a medical post, depending on the availability of a boat, river water level, and village of departure (Wilson and Bulkan, 2004). These data suggest that season nutritional intake may be negatively correlated with an increasing degree of village isolation. During wetter periods, rates of malaria infection are highest in these isolated villages (Forte, 1996; Wilson and Bulkan, 2004), which may compromise nutritional status.

The food types that demonstrate significant seasonal differences in contribution to energy intakes are those most strongly associated with the Makushi seasonal subsistence calendar (i.e. fish, game, wild and cultivated fruits and vegetables). It is, therefore, not surprising that these foods, the activities surrounding which are seasonally influenced, exhibit significant seasonal variation in dietary contribution. Additionally, flour and rice show seasonal differences in contributions to energy intake among several age and sex cohorts. Flour provides significantly more energy to the dry season diet of female children. Flour is an ingredient in baked, non-manioc bread that is quite popular among children. In April 2003, parents reported that children often asked for baked bread, as this was preferred over the traditional manioc bread. This request may be due to a monotonous dry season diet and the apparent novelty of western-style foods. Among male adults, flour and rice contributed more energy to the diet in the dry season. In a season of generally low food variety, male adults may be filling up on flour and rice in the absence of other food to eat. Are store-bought foods compensating for low supplies of cultivated or wild food resources? If so, what is causing the under-production of cultivated or wild food resources, or manioc products? An assessment of the availability of food items typically associated with the dry season, such as fish and manioc products, may clarify why an increased dependence on store-bought foods items occurred during this season.

To summarise, these village-based significant seasonal changes in dietary intake, based on age and sex cohorts, may be caused by one or more of the following: environmental/geographic factors, village isolation, sex-related activity patterns, or age-related nutritional intake. Food availability and healthcare is determined by the geographical location and isolation level of each village, whereas an individual's age and sex may establish how much and what type of food is available or consumed. Female children are exhibiting seasonal changes in energy and protein intake, which may be due to a combination of preferential feeding patterns or increased labour demand of mothers. The seasonal changes found among female adults, specifically greater wet season vitamin A intake and food variety, may be a product of their own activity patterns. Additionally, the proximity of villages to farms and forested regions may be reflected in the diet of female adults. Given that specific age and sex cohorts (female children and female adults) exhibited significant seasonal nutritional differences, this encourages support for the second hypothesis. Additionally, this data suggests that not all members of the Rupununi Makushi population have adapted to the seasonal availability of food resources in the same manner.

6.4 Functional Implications

Seasonal nutritional shortages among the Makushi may have functional implications for childhood growth and development. These shortages have resulted in an overall, combined villages dry season diet deficient in vitamin A, which can lead to visual impairment and blindness, and significantly increases the risk of severe illness, or death, from common childhood infections such as diarrhoeal disease (WHO, 2003). West and colleagues (1988) report links between vitamin A deficiency and its ocular symptoms to stunted linear growth and wasting in children, although this relationship has not been consistently observed (Begin et al., 1992). Furthermore, higher dietary variety was found among male children (combined villages) and among several male and female children and adult cohorts (individual villages) in the wet season, and among female adults in Surama and male adults in Massara in the dry season. High dietary variety is associated with a better diet (Dangour, 1997; Foote et al., 2004). Therefore, decreased dietary variety for some Makushi age and sex cohorts during the dry season may compromise their growth.

The potential impact on adults is unclear. Research on adults in the Gambia, India, Benin, Ethiopia documents that people adapt to "hungry seasons" in these regions by decreasing daily energy expenditure, allocating important domestic and labour to children and adolescents (Brun et al., 1981), and/or participate in post-harvest feasting, which should lead to weight gain and improved nutritional status for planting periods that require increased energy expenditure (Dugdale and Payne, 1986, 1987). Seasonal food shortages may lead to changes in food types consumed and food sources. Van Liere et al. (1995) report that seasonal food shortages in the commune of Manta in northwestern Benin cause a shift to less-preferred food types, food gifts, and store-bought foods. While a stable food supply may result in a constant or growing population, seasonal variations in food supply may limit population growth. Therefore, a hungry season may impact the Makushi by influencing their activity patterns; adults may become less active during periods of hunger or greater physical demands may be required of Makushi children and adolescents. Food choices may be altered during food shortages causing the Makushi to depend on food gifts or store-bought foods provided available financial resources.

Notwithstanding the insufficient nature of the Makushi diet for the two months studied, Makushi adults appear healthy and active. The stature and BMI for the Makushi adults were largely consistent with measurements of other Amerindian populations (see Chapter Two); that is, there were large percentages of stunting and no wasting among individuals > 12 years of age. Therefore, anthropometric measurements show that adult BMI are within an accepted range. There are two possible explanations for this finding. The Makushi adults must be adequately nourished in the months not covered in this research, or the dietary data on which this research is based is incorrect.

A confounding factor regarding the apparently healthy nature of Makushi adults involves establishing nutrient recommendations. RDA is based on the estimated average requirement (EAR) of a given nutrient, an amount that appears sufficient to maintain specific bodily functions in half the population (Whitney and Rolfes, 2002). Given that not all members of a population have the same nutritional needs, the RDA is set high enough above the EAR to meet the requirements of most healthy people. Given that many Makushi adults are consuming below RDA for fat, they may be consuming adequate amount of dietary fat to meet their requirements. In contrast to nutrient RDA, the value set for energy is not generous. The RDA for energy is set at the mean of the population's estimated requirements, with half of the population's requirements falling below it and half above it (Whitney and Rolfes, 2002). Makushi adults exude health and happiness that may indicate that their dietary intake is within their specific nutritional requirements.

6.5 24-Hour Dietary Recalls vs. Semi-Structured Interviews

A secondary goal of this thesis is to compare two different dietary intake data collection protocols: 24-hour dietary recalls and semi-structured interviews for dietary recall. As noted in Chapter Four, 24-hour recall interviews are recommended for large sample populations and provide estimates of average food intake comparable to more thorough methods (Beaton et al., 1979; Ahluwalia and Lammi-Keefe, 1991), while semi-structured interviews for dietary recall are recommended for situations where there is limited opportunity to complete interviews and requiring casual conversation (Bernard, 2002). While the collection of dietary intake data in these manners may afford an opportunity to evaluate the reliability and validity of each interview strategy, it is important to keep in mind that these methods were utilised for different reasons. The 24-

hour dietary recalls were collected to provide an overall picture of dietary intake in this region. The semi-structured interviews for dietary recall were conducted to help ascertain whether or not the Makushi perceive any differences in dietary intake by season and, if so, what the consequences might be and how might they adapt to seasonal variations in food supply. Despite the different goals, similar results were expected as both methods are considered valid and reliable. However, given that the interviews were conducted at the end of the dry season, informants may have been biased by their anticipation of wet season foods.

Similarities in the results of the two methods were indeed found with regard to the dietary staple. A comparison of the frequency of consumed food items in the 24-hour dietary recalls and semi-structured interviews highlights the importance of the staple crop, manioc, in the Makushi diet. The interviewees listed *farine*, *casareep*, *tapioca*, and manioc bread among the 15 most frequently consumed foods during both seasons, and the 24-hour recalls recorded *farine* as the most frequently consumed food during the wet and dry season.

While similar with regard to the staple crop, the results of the two methods differed in a number of instances. As noted above, fish is traditionally considered an important nutritional contributor in the dry season. The interviewees identified seven of the top 15 most frequently consumed dry season foods as fish. However, fish was recorded more often in the 24-hour recalls during the wet season. The interviewees identified game (agouti, meat, labba, and deer) with the wet season, whereas game does not appear on the top 15 foods recorded for the wet season in the 24-hour dietary recalls which, surprisingly, recorded game more frequently in the dry season. The seemingly counter-intuitive frequency counts may be illustrating how the Makushi use food resources when they are scarce. The Makushi may be consuming fish more frequently in the wet season and game more frequently in the dry season, but in smaller quantities, thus providing less, nutritionally. For example, the paucity of game in the dry season may make it a food worth savouring often, but in small amounts to lengthen the time it may be enjoyed 'out of season'. In April of 2003, during the dry season, several varieties of dried game, such as deer and beef, were being sold in several villages, which could be purchased in small amounts. The same explanation may account for the high fish frequencies in the wet season. Fish is dried and salted for preservation. While conducting interviews, two adult females complained of the dearth of fish in the wet season and commented that they sometimes only had a "small tail piece" to flavour the *tuma*.

Further dissimilarities between the results generated by the two methods concerned cultivated foods. Contrary to both Forte (1996) and the semi-structured interviews, the 24-hour recalls showed that cultivated fruits and vegetables were more frequently recorded during the dry season, and they contributed significantly more energy to dry season diet when all villages were combined. However, the Makushi interviewees did not associate cultivated foods with the dry season, with only yam appearing in the top 15 (13^{th}) most frequently consumed foods. This may be due to the fact that food plants grown in family farms and kitchen gardens are planted shortly before the anticipated beginning of the rains. Cultivated plants have, on average, a four month growing season. Hence, the nutritional benefit of the long wet season rains is not realised until late

September and October, during the dry season, when the plants are ripe for consumption. The interviewees may be relating the activities surrounding the production of cultivated plants, which occur in the wet season, with the actual consumption of cultivated foods, which appears to occur in the dry season. Those cultivated plants that do ripen during the wet season may not contribute a considerable amount to the Makushi diet.

Wild foods, traditionally associated with the wet season, were not among the 15 most frequently consumed foods in either season for the 24-hour recalls, and the interviewees associated them with the dry season. Wild food resources most energetically essential to the Makushi diet seem to ripen in the wet season, as wild foods contribute significantly more to wet season energy intake when considering combined villages. The greater dry season prevalence of wild foods may be due to the fact that several of the wild foods consumed by the Makushi reach maturation in the dry season. For example, lu palm (sp. unknown) fruit ripens in November through April, kokerite (*Maxmiliana regia*) from March into the rainy season, and savannah cashew (*Anacardium occidentale*) in February and March (Forte, 1996). Observations of wild food consumption for one month in the dry season indicate that they are consumed regularly, albeit in smaller quantities. The relative ease of dry season travel may make the collection of wild foods more feasible and, therefore, consumption more frequent. The wild food varieties that ripen in the dry season tend to do so during the dry period following the short December through January rains. A difference in dry season frequency of wild food consumption may be distinguished if all dry season 24-hour dietary recalls included in this study were taken from the dry season period before the short rainy period (October and November).

The dissimilarities in the results acquired from the 24-hour recalls and interviews are difficult to explain, but may be attributed to several factors. First, the different methods employed are based on data collected over two time spans. Second, the methods collected two different types of data. The 24-hour recalls indicate dietary intake over a long-term, which may be more indicative of seasonal trends, while the interviews consisted of immediate responses, which may suggest the proximate dietary situation among the Makushi. When asked about foods commonly consumed in the wet season and the dry season, the Makushi neglected to mention those foods that are consumed throughout the year. Instead they listed foods that they seem to closely link with wet season or dry season availability. This may indicate nostalgia for seasonally available foods, and may over-accentuate the differences between the two methods. Third, results obtained from each method accumulated widely differing amounts of data. Whereas the 24-hour recalls data set consists of 723 intake days and 197 participants, the interview participants numbered 41. While these factors may be a part of the explanation, more fieldwork with these informants is clearly necessary to address this. Fourth, as noted above, the 24-hour dietary recalls were collected to provide a general picture of Makushi dietary intake, while the semi-structured interviews for were performed to establish whether or not the Makushi perceive any differences in dietary intake by season and, if so, what the consequences might be and how might they adapt to seasonal variations in food supply.

Despite these differences, the two methods used in this study are complementary. The 24-hour dietary recalls surveys record a considerable amount of personal, household-level, and dietary information that, when balanced with group interviews and researcher observation of the participant milieu, provide multiple perspectives of dietary behaviour. The results illustrate interesting similarities and differences in seasonal dietary intake that demonstrate the complexities of the actual and perceived effects of seasonality on the Makushi diet. The similarities bolster the view of the important contribution of the dietary staple, manioc, during both seasons.

The differences between these two approaches are important as they illustrate potential inaccuracies of the methods. Of the two approaches 24-hour dietary recalls are considered a more objective, reliable, and thorough measure than single, unstructured interviews (Buzzard 1988). Long-term recall, particularly in a group interview, is subject to constant revision. A comparison of the results of these methodological approaches illustrates this revision.

6.6 Limitations

This study has limitations relating to the nature of the data collected. Several factors potentially limit the accuracy to which the nutrient content of the diet was evaluated in the present study. First, the variability in nutritional content between the foods indigenous to the Rupununi region of Guyana and the substitutes found in NATS 2.0 is not known. However, the substituted food items were wild and infrequently consumed, so that any error occurring in the calculation of nutrient content should have only a minor effect on the results. The nutritional composition of wild fruits and vegetables indigenous to South America has not been well studied. Further investigation in this field is necessary and will ameliorate studies of nutritional intake among indigenous populations. Second, participants of the 24-hour dietary recalls may not account for food eaten away from home, thus underreporting consumption of wild plants and small animals.

As 24-hour dietary intake data were not available for all villages in each of the twelve months of the initial survey, the same months were not available for the comparison of wet and dry season diet. This may have potentially impacted the results, especially given the accessibility and variety of food resources of each village.

6.7 Further Research

While the pattern of dietary intake varies among age and sex cohorts, this research indicates that Makushi dietary intake is affected by seasonality. The lack of consistency in the results suggests that the first hypothesis, which proposed that seasonality affected patterns of nutritional intake, could be refined to focus on particulars of seasonal variation.

The impact of seasonal patterns on the status and adequacy of the Makushi diet is complex, and brings to light numerous social, cultural, economic, and health factors that are interrelated with seasonality. Food getting strategies and outcomes differ at the level of the individual, household, and village. Strategies implemented to overcome the seasonality of food supply are continually undergoing change, adapting to concurrent alterations in the surrounding sociocultural and biological environment (Pelto, Goodman, and Dufour 2000). The literature described within clarifies this complexity and offers methods and highlights areas of research that need to be targeted to examine adaptations to seasonality and its human dynamic.

Several paths of investigation are suggested for future endeavours in nutritional anthropology. First, there is a general need to be more attentive to intrahousehold distribution of food, in terms of quality and quantity. Future studies should examine whether the distribution of food in Makushi household is equitable or favours certain age or sex cohorts. In the case of the Makushi, the number, scheduling, content, and structure of meals seems to be primarily determined by seasonality and the female head, whose activity and behavioural patterns can importantly affect how much and what type of food is consumed, especially among children. The allocation and use of female time is partly governed by seasonality and may be affecting household nutritional status.

Second, generating knowledge of the relationship between nutritional seasonality and household structure can lead to more efficient allocation of resources for regional aid programs. For example, targeting nutrient-dense foods for particular age and sex cohorts is difficult in indigenous populations that habitually eat from a common pot. Alternative solutions include nutritional education programs and fortification of foods commonly consumed (Berti, Leonard, and Berti, 1997).

Third, research in nutritional anthropology requires a focus on why people eat what they eat and why people do not eat certain foods. Food restrictions and cultural notions of 'healthy' and 'unhealthy' foods were not directly investigated in this thesis, but should be examined in the future. Do food taboos restrict the Makushi diet, thus compromising dietary adequacy already challenged by seasonality? For example, among the Makushi, pregnant and lactating females are prohibited from eating small game animals as they are thought to negatively impact infant health (Forte, 1996).

Fourth, knowledge of social networks is important. Social networks provide flexibility and opportunities for alleviating food shortages caused by seasonality (Messer, 1989). Conceptual questions to be considered include the system and practises for making demands on relatives or neighbours, and the effect of family and village cohesion on dietary intake. More studies are required to investigate whether the income generated from wage labour is sufficient to compensate seasonal food shortages, or if purchased foods are compromising diet further.

CHAPTER SEVEN: CONCLUSION

Anthropologists have investigated seasonality from both biological and sociocultural viewpoints, and have revealed how the seasonal cycles and the availability of plant and animal food resources have structured human subsistence strategies and livelihood. This thesis examines the potential impact of seasonality in rainfall and temperature patterns on the nutrition among the Makushi, which may, in turn, affect their growth and development.

Contrary to expectations, this thesis concludes that, overall, the nutritional intake of the Makushi is not influenced by seasonal patterns. The Makushi have adapted to the seasonality of food resources by following a calendar of subsistence activities that incorporates exploiting food resources when they are plentiful. However, when considering the impact of seasonality on specific age and sex cohorts, this thesis documents that the diet of several of these cohorts does vary seasonally.

As suggested in Chapter One, the conclusions of this study have several implications. Overall, the diet of the Makushi does not appear to be affected by seasonality, but is inadequate for the months studied during the wet and dry season. This study proposes, then, that investigations of dietary seasonality require long-term analyses of nutritional intake spanning over several seasons. Several age and sex cohorts demonstrate significant seasonal variations in nutritional intake. These findings indicate that all members of Makushi society have not adapted to the same degree to the seasonal patterns of lowland South America. The dietary, growth, and development patterns found among the Makushi, especially female children and adults, may be due to seasonality, but this study suggests that food distribution patterns, the role of the household head, and cultural and symbolic beliefs also differentially influence nutritional intake in the family. This may imply that adaptations to seasonality are society-specific, but further comparative studies are required to adequately test this proposal.

This study has verified the efficacy of implementing two different methods of evaluating nutritional intake, 24-hour dietary recalls and semi-structured interviews. Research in nutritional seasonality and adequacy will be enhanced with each completed study that may be used for comparative purposes.

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Appendix A: Semi-structured interview questions

1. Do the foods consumed by you and your family vary throughout the year?

2. If not:
    a. Why not? (i.e Do you harvest manioc year-round? Do you purchase foods at the store? What foods do you regularly consume year-round?)

3. If yes:
    a. How do the foods vary?
    b. Does this variation cause any hardships (i.e. health, emotional, or social problems?)
    c. How do you cope with the variation in food supply?
    d. Do you and your family enjoy variation in the food supply?

4. Does the amount of food consumed by you differ from the amount of food consumed by your children? Your husband?

5. If yes:

    a. Do you consume more or less than your children/husband?
    b. Why do you consume more/less than your children/husband?

6. Can you think of any circumstances (seasonal, illness, financial) that may influence the types of food available, or make food-getting difficult?

Appendix B: Species of fish and wild fruit consumed by the Makushi

Food Type	Common Name	Scientific Name
Fish	Arawana	*Osteoglossum bicirrhosum*
	Perai	*Serrasalmus* sp.
	Lukunani	*Cichla ocellaris*
	Paku	*Metynnis* sp.
	Hassar	*Hoplosternum* (Callichthyidae)
	Houri	*Hoplias malabaricus*
	Kassi	*Rhomdia holomelas*
	Tigerfish	*Pseudoplatystoma* spp.
	Dare	*Leporinus* sp.
	Yakutu	*Prochilodus rubrotaeniatus*
	Patwa	*Cichlasoma* sp.
	Basha	*Plagioscion* sp.
	Manji	*Magalonema platycephalum*
	Yarrow	*Hoplerythrinus unitaeniatus*
	Kulet	*Hoplerythrinus unitaeniatus*
	Imheri	*Trachycorytes galeatus*
	Haimara	*Hoplias macrophthalmus*
	Dawala	*Ageneiosus ogilviei*
	Diamond fish	*Pseudodoras* sp.
	Banana fish	*Pseudodoras* sp.
	Catabac	*Myleus rubripinnis*
	Baiara	*Hydrolycus scomberoides*
	Policeman fish	*Prochilodus rubrotaeniatus*
	Zip fish	*Megalodoras* (Doradidae)
	Serebe	*Astyanax* sp.
	Swordfish	*Boulengerella cuvieri*
	Foxfish	*Acestrorhynchus* sp.
	Larima	*Acestrorhynchus* sp.
	Fine fish	*Astyanax* sp.
	Red tail	*Acestrorhynchus* sp.
	Silverfish	*Astyanax* sp.
	Sunfish	*Crenicichla* sp.
	Lau Lau	*Brachyplatystoma* sp.
Wild Fruit	Bora	*Vigna unguiculata*
	Boulanger	*Solanum melongena*
	Corro	
	Whitey	
	Jamoon	*Syzygium cumini*
	Kokorite	*Maximiliana regia*
	Fat pork	
	Isciby	
	Awara	*Astrocarytum tucuma*
	Meite	
	Hitcha	
	Five finger	*Averrhoa carambola*
	Saweta	
	Chiou	
	Conkee	