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Journal of Anthropological Research is currently published by University of New Mexico.

SEASONALITY IN A FORAGING SOCIETY: VARIATION IN DIET, WORK EFFORT, FERTILITY, AND SEXUAL DIVISION OF LABOR AMONG THE HIWI OF VENEZUELA[1]

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In this paper we describe seasonal variation in the diet, subsistence work effort, and sexual division of labor among Hiwi foragers of Venezuela. The major findings are: (1) The Hiwi diet is characterized by stability in hunted resources but extreme seasonality in vegetable resource types. (2) Men and women show significant seasonal variations in subsistence work effort and, therefore, in the character of the sexual division of labor. (3) Significant seasonal weight changes for each sex are observed. (4) Female fertility patterns vary seasonally, and this variation appears to be highly correlated with changes in "net" energy intake throughout the year. We suggest that a consideration of the individual fitness consequences of behavioral options for each sex may provide some insight into sex differences in behavior across seasons.

SEASONALITY HAS LONG been considered an important factor affecting human societies. Because seasonality influences the food supply, and this in turn constrains many other aspects of economic and social life, simple changes in rainfall and temperature patterns can result in an almost endless array of subsequent ramifications that may ultimately influence work patterns, marriage, social structure, and ritual cycles. In addition, seasonal extremes in food supply or weather conditions may represent the most important constraints on long-term physical and behavioral adaptations (Liebig's Law of the Minimum). Thus studies of extreme seasonal conditions among hunter-gatherers may provide useful insights into the selective pressures responsible for the evolution of a wide variety of human characteristics.

While the appreciation of economic seasonal trends in agricultural groups is generally unavoidable because of planting and harvesting cycles (e.g., Dugdale and Payne 1987), few quantitative studies of seasonality in foraging (hunting-gathering) societies have been published (Wilmsen 1982; Bailey and DeVore 1989; Hill et al. 1984). This is surprising given that many ethnographers have been quite explicit about the importance of seasonality among foragers. Studies suggest that seasonality affects patterns of diet, work effort, group size, mobility, warfare, and ritual on all continents and at all latitudes (e.g., Africa: Silberbauer 1981; Lee and DeVore 1976; Hawkes, O'Connell, and Blurton Jones 1989; Asia: Cipriani 1961; Griffin 1984; Eder 1968; Watanabe 1968; Australia: Meehan 1975, 1982; D. Thomson 1983; North America: Steward

1938; Downs 1966; Hoebel 1978; Damas 1972; South America: Holmberg 1950; Gusinde 1961; Dieter 1972). The most common patterns reported are that changes in the seasonal abundance of some food resources promote shifts from small mobile social groups to large sedentary ones, thus influencing mating patterns and ritual activity. Regular seasons of bad weather also appear to limit travel, visiting, and intergroup conflict.

In the most extreme description of seasonal effects, Donald Thomson's 1939 study in Arnhem Land suggested that differences between the wet and dry seasons in group size, mobility, diet, tool usage, and ritual activity were so pronounced that a naive observer might easily conclude he was observing two different "tribes" of people (D. Thomson 1983). In contrast, our own studies of seasonality among the Ache of Paraguay suggested that changes in rainfall and temperature had only minor effects on diet and activity patterns (Hill et al. 1984; Hill 1983:210).

Most previous research on seasonality among subsistence agriculturalists and hunter-gatherers has focused on food consumption (Fox 1953; Calloway 1982a; Dugdale and Payne 1987). This is not only because energy and protein intake is an important determinant of long-term population and individual variation in nutritional status, but because poor diets also generally have negative effects upon children's growth rates (Flowers 1983; Billewicz 1967; McGregor, Billewicz, and Thomson 1961; A. Thomson 1977) and, ultimately, upon various biological components of fitness such as fecundity (Crook and Dyson 1981; Becker, Chowdhury, and Leridon 1986) and child mortality (Brown et al. 1985; Chambers, Longhurst, and Pacey 1981:103–34).

Although dietary variation is often described, work seasonality has been studied relatively less, even though adequate energy balance is the product of both dietary intake and energy expenditure. Indeed, work effort differences may be more important than food consumption when the individual members of a society are examined. Although food is often pooled to some extent, especially between spouses in a nuclear family, work patterns are very sex specific. A review of the literature on hunter-gatherers shows that there are marked differences in adult male and female subsistence strategies in all groups studied and that the extent of these differences appears to be affected by seasonal changes in the local ecology (Hurtado 1985).

To the extent that male and female subsistence behaviors differ, and to the extent that these differences have consequences for food consumption and energy expenditure, food and work seasonality are likely to affect differentially the health status of the sexes in foraging societies. Sex differences in energy expenditure across seasons coupled with temporal fluctuations in energy intake may produce peaks and troughs in female and/or male fertility (see Ellison 1989 for a review). Although seasonal changes in the diet or work effort and their effects on the weights of adult males and females have been reported for some groups of foragers (e.g., Wilmsen 1982; Hill et al. 1984; Hawkes, O'Connell, and Blurton Jones 1989), the relationship between seasonal fluctuations in caloric consumption, sex differences in time spent foraging, health status,

and fertility has not been systematically studied in foraging societies. The literature on societies with more complex social structures provides little insight into this problem: although seasonal fluctuations in birth rates appear to be a universal phenomenon in human societies (see Leslie and Fry 1989 and references therein), our current understanding of the causes of this variation is very poor.

Finally, the opportunities for natural experimentation that are facilitated by seasonal variability have not been fully appreciated in behavioral studies of hunter-gatherers. Since many of the important dependent variables of interest (e.g., sexual division of labor, group size, mobility) show seasonal changes, it is hoped that the relevant independent variables responsible for these patterns will be discovered by examining seasonal changes. These descriptive associations can then be used to develop models specifying the relationship between ecological conditions and behavioral outcomes. The stratification of behavioral observations according to seasonal changes in the independent variable of interest allows us to test these models. Thus an examination of seasonality presents an exciting opportunity for testing propositions concerning the temporal and spatial distribution of behavior.

In this paper we describe seasonal variation in the diet, subsistence work effort, and character of the sexual division of labor among Hiwi foragers.[2] We also describe seasonal fluctuations in adult weights and in women's fertility and consider factors associated with this variation. We discuss several issues that arise and suggest that a consideration of the available alternatives and the individual fitness consequences of each behavioral option for each sex may provide some insight into these puzzles.

BACKGROUND

The sexual division of labor, ethnographic background, and diet of Venezuelan and Colombian Hiwi populations have been partially described in several publications (Coppens 1975; Fonval 1976; Arcand 1976; Hurtado and Hill 1986, 1987). Preliminary analyses of demographic data have also been published (Hurtado and Hill 1987).

This paper describes seasonal variation in the subsistence strategies of Hiwi hunter-gatherers of southwestern Venezuela.[3] This population lives in the extremely seasonal neotropical savannas of the Orinoco River basin (Cole 1986), where a larger population of closely related Guahibo-speaking peoples resides. Although all the Guahibo-speaking populations refer to themselves as "Hiwi," in this paper the term "Hiwi" is used to refer exclusively to the hunting and gathering bands of the Guahibo population, as no other adequate label is available. For these bands, the local *criollo* populations use the term "Cuiva," which has strong derogatory connotations.

Even though the Hiwi are linguistically and culturally similar to other Guahibo groups, their economic patterns are quite different (see Metzger and Morey 1983 for reviews). Most Guahibo speakers are subsistence agriculturalists

residing along the alluvial plains of the lower Meta, Tomo, Tuparro, and Vichada rivers in Colombia and along the middle Orinoco River between the Villacoa and Cuao rivers (Metzger and Morey 1983). In contrast, the territory of the Hiwi, who have been described since earliest reports as nonagriculturalist hunter-gatherers, is confined to the drainages of the upper Cinaruco, Capanaparo, Cinaruco, Ariporo, Agua Clara, and Meta rivers. The spatial distribution of Guahibo-speaking agriculturalists and Hiwi foragers may be determined in part by soil type, drainage, and the size of alluvial plains: Hiwi foragers inhabit poorly drained, clayey savannas and river headwaters, while agriculturalists occupy well-drained, sandy savannas and gallery forests along the lower courses of rivers, where alluvial plains are more extensive (Cochrane et al. 1985).

ECOLOGICAL AND SOCIAL FACTORS

Social, ecological, and historical factors play an important role in the contemporary behavior of Hiwi hunter-gatherers. The Hiwi inhabit a neotropical savanna (*llanos*) that floods annually. Flooding is followed by a dry spell that lasts several months. The ecological consequence of this rainfall regime is a marked fluctuation in the temporal and spatial distribution and in the biomass and productivity of plants and animals.

The llanos are characterized by extensive grasslands, with belts of gallery forests one to two kilometers in width found along main rivers and some creeks. Their major boundaries include the Venezuelan Andes, the coastal mountain range (Cordillera de la Costa), the Orinoco River, and the Vichada River (the border of the Amazon tropical forest). The main territory of the Venezuelan Hiwi is confined to areas contiguous to the Cinaruco River.[4]

Rainfall, Temperature, and Soils
One of the most important ecological features of the llanos is their unimodal rainfall seasonality. Close to 90 percent of the precipitation falls during the months of May through November, followed by an intervening period of severe moisture stress between January and March. During these dry months, monthly precipitation averages fall below 25 millimeters (MARNR 1987; see Troth 1979:18), and often there is no rain in January and February (Figure 1). The north wind blows almost constantly, lakes and lagoons dry up completely, and savanna grasslands wither and die.

Temperatures are relatively constant throughout the year, with a difference of only 1.9° C between the mean daily temperature of the coldest and warmest month. Mean extreme temperatures are somewhat variable, however, ranging from an average daily maximum of 37.7° C in March to an average daily minimum of 19° C in December (Troth 1979:19) (Figure 2).

The soils of the Venezuelan llanos are generally acidic, sandy, deficient in potassium, and poorly drained, with little potential for agricultural production.
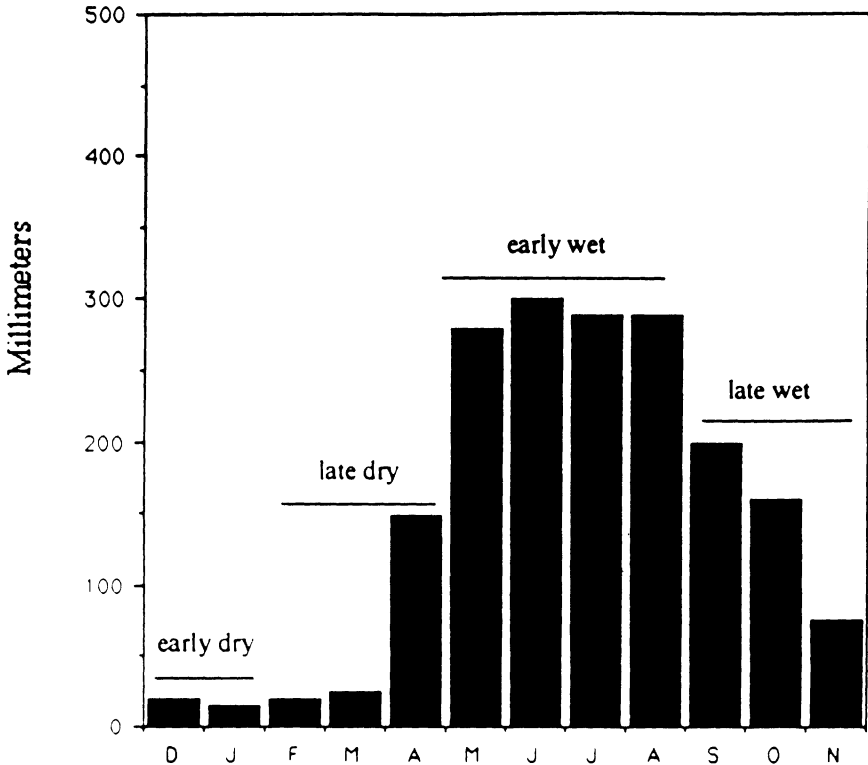
Figure 1. Mean Monthly Rainfall in the Lower Llanos (from MARNR 1987)

The Spatial and Temporal Distribution of Wild Foods
   In the lower llanos, microrelief and degree of inundation are responsible for
the uneven and patchy distribution of floral and faunal species. Ecologists have
identified five physiographic units in the Venezuelan llanos: *médano* (sandhill),
banco (nonflooded, low ridge), *bajío* (moderately flooded lowlands), *estero* (more
deeply flooded lowlands), and gallery forests (Troth 1979). The gallery forests
are well drained and flood minimally.
   These physiographic units are differentially exploited for food and other
resources by the Hiwi. The médanos are important for the palm *Mauritia
minor*, an important source of food staples and materials (palm fruits, palm
heart, and leaves and wood for manufacturing baskets, bags, and bows). During
the dry season, bajíos and esteros are the primary foraging ground of grazers
such as deer and capybara, and during the wet season when the savannas
flood, fish exploit abundant palatable grass species at these sites (see Troth
1979:27). One of the Hiwi's more important carbohydrate staples, the "oyo"
tuber (*Banisteriopsis* sp.), grows in extensive patches in bajíos and esteros.
Other tubers are found in dense clumps along the transitional zone between
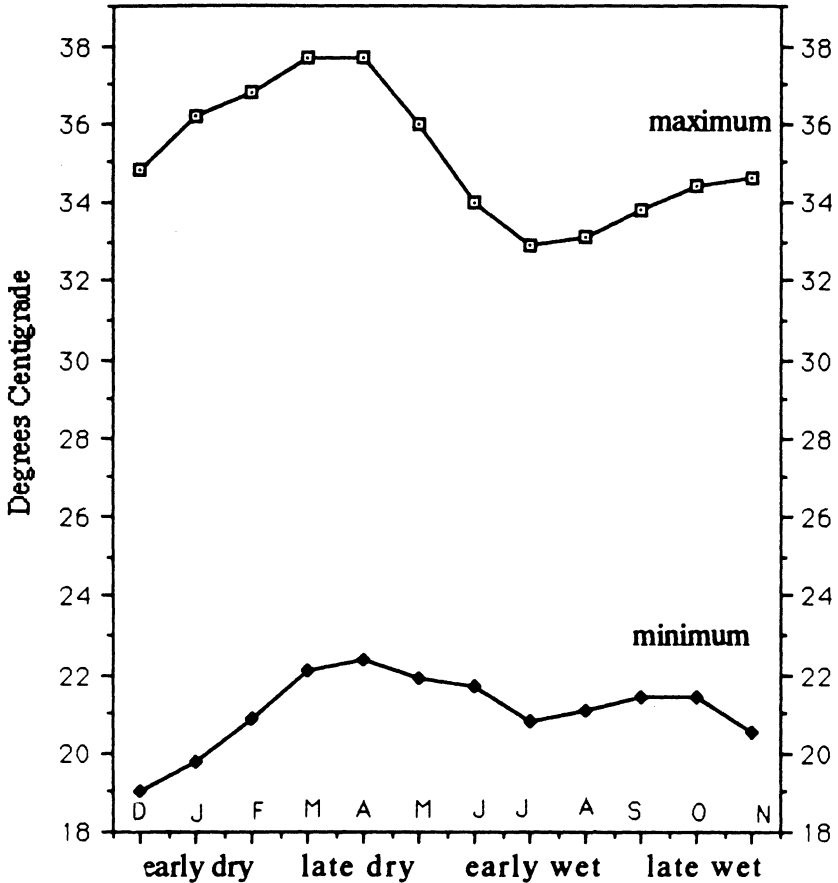
Figure 2. Mean Monthly Temperature in the Lower Llanos of Venezuela

the gallery forest and the savanna (e.g., *Dracontium asperum*, *Calathea allonia*, and *Cannas edulis*). Fruiting trees are primarily found in the gallery forest, while legume-producing trees (mainly *Campsiandra comosa*) grow along the edge of the gallery forest that faces the riverbanks.

Changes in the water level have important consequences for the distribution of faunal species across seasons. When the waters recede during the dry season, fish remain trapped in pools that are formed in the bajíos and esteros. These water sources also become attractive grounds for caiman, capybaras, and turtles. The animal biomass of these ponds during the dry season is quite high (Eisenberg 1979) and becomes a primary hunting target of Hiwi hunters.

In contrast, flooding during the wet season disperses fish, turtles, and caiman over huge expanses of savanna, while large mammals (deer, capybaras, peccaries, and anteaters), on the other hand, seek refuge in gallery forests. Not surprisingly, the gallery forest becomes the preferred foraging ground for the Hiwi during this time of the year. During both seasons of the year, canoes are

the major form of transport to hunting patches. Canoes are also frequently used in the pursuit of riverine and semiaquatic game.

Group and Territory Size

The Hiwi population of both Venezuela and Colombia in the 1980s is unknown, primarily because of the social chaos brought on by drug trafficking and guerrilla warfare along the Colombian and Venezuelan border in recent years. In the 1970s, however, Arcand (1976) estimated that the total Hiwi population in both countries was approximately 800 individuals.

The population of the Venezuelan Hiwi hunter-gatherers was 290 individuals in the 1988 dry season. These individuals comprise two semipermanent residential bands which are further subdivided into factions. The bands form very large camps including all members of the band during much of the year, but they also break up into smaller bush camps for periods of up to four weeks at a time. The two residential settlements are located near the Cinaruco River within a four-hour walk of each other on a reserve bounded by two rivers and an incipient cattle ranch; in 1971 a presidential decree set aside 12,058 hectares for the reserve (Hurtado 1986).

The larger band (188 individuals), which we refer to as the Jicutimene band, is settled in the middle of a dry savanna next to the local Indian services office (see Hurtado and Hill 1986, 1987). The smaller band (102 individuals), which we refer to as the Cinaruco band, prefers to live in the gallery forest along the Cinaruco River. Its central place has been moved several times over the past twenty years. Logistical difficulties have curtailed all attempts to implement economic, medical, and social programs in this second band. This more isolated group of Hiwi, the Cinaruco band, is the focus of our investigations.

Social Organization

The nuclear family plays an important economic and social role in Hiwi society. Preliminary analyses of demographic data suggest that the Hiwi form long-lasting marital bonds that are usually monogamous. In addition, food distribution observations indicate that plant and animal resources are preferentially shared within the nuclear family of the acquirer or with close kin (Lyles, Hill, and Hurtado 1990). At the same time, time allocation data suggest that married couples spend a great deal of time together, both in camp and out of camp, and that they frequently cooperate in food acquisition activities. This pattern is in striking contrast to other native South Americans that we have observed and was noted by Arcand as well.[5] The extent of cooperation between couples varies greatly across seasons.

Cooperation beyond the nuclear family also appears to be heavily influenced by kin relationships. Alliances between families divide the villages into various factions. As seasons, settlement, and movement patterns change, these factions make predictable moves into and out of the village throughout the year. Even though Hiwi villages choose only one leader to represent them in confrontations with other villages, several men within the village appear to informally represent these loosely organized factions in intravillage politics.

HISTORICAL FACTORS

The first peaceful contact between cattle ranchers and Venezuelan Hiwi took place in 1959. The ranchers who initiated contact hoped to end the frequent violent encounters and incidents of cattle theft that had characterized inter-ethnic relations in the area since the early 1900s. They were also interested in obtaining inexpensive labor that they believed the Hiwi might provide. Two bands of Hiwi, whose traditional territories were located about a hundred kilometers apart, were convinced to settle together in the Cinaruco band's territory because it was closest to a criollo village. In return, the Hiwi were offered protection from the violent incursions of other cattle ranchers. The Hiwi were easily convinced; within a few months of peaceful contact, a band of approximately thirty individuals who failed to move to the protected area was massacred along the upper Cinaruco River.

By agreeing to live relatively close together along the same river, the two Hiwi bands may have compromised access to a larger food supply. According to informants, the immigrant group was relegated to the less productive habitats, while the resident group, to this day, is in control of most of the best foraging patches. Over the years, the two groups have staked out two "territories" within their land reserve and adjacent riverine areas, and they forage almost exclusively within their own territory. Members of either band are sometimes beaten or killed when encountered in the neighboring band's territory. The larger newcomer band forages downstream from their settlement and along all downstream tributaries for about 40 kilometers to the south of the settlement of the resident band. The smaller resident band forages upstream for about 50 kilometers to the headwaters of the Cinaruco. Hostile interactions and overt warfare between the two groups have been the norm since at least 1974; sporadic killings have taken place as late as 1986.

In conclusion, a highly seasonal savanna environment and a shrinking food resource base probably shape the subsistence patterns of Hiwi hunter-gatherers in important ways. We describe below the behavior of Hiwi men and women and some of the constraints imposed by this ecological setting.

METHODS

The Study Site

Food acquisition, anthropometric, and demographic data were collected among the band of Hiwi which resides in the gallery forest. The behaviors of adult Hiwi were sampled at two different sites: first, in 1985–86, at the Estéban location (Hurtado and Hill 1987), and then, in 1987–88, at their most recent settlement. This relocation was prompted by a devastating raid and one homicide executed by members of the enemy Hiwi band. Because the Cinaruco band that we chose to study occupies the more abundant sectors of the Hiwi territory, mobility and dispersal are less pronounced than among the other

band. Consequently, we were able to do most of our data collection at a central place and on a larger number of people on any given sample day than would have been possible among the more nomadic inhabitants of the savanna settlement. It is important to emphasize that the behavioral profile described here is *restricted to a central-place settlement only*. Data analyses of subsistence behaviors in temporary, small bush camps will be discussed elsewhere. On 85 percent of all Hiwi person-days, individuals slept in the central place settlement; on 8 percent of all person-days, they slept in temporary camps; on 4 percent, they worked in nearby cattle ranches; and on 3 percent of sample days, they attended celebrations at a local criollo village.

Data Collection

The analyses described here are based on data collected in November and December 1985, April 1986, July 1987 and 1988, and from December 1987 until May 1988, for a total of 185 days in residence at the field site. The actual dates of sampling during field periods over the four years of this study are shown in Tables 1 and 2 (see below). For the study on seasonal changes in food consumption, foraging behaviors of adults, nutritional status, and reproduction, we collected data on time allocation, food acquired, edible portions, adult weights, and birth seasonality.

Collection of the first three types of data involved noting all individuals who left camp and with whom they left (analyses of in-camp activities will be reported elsewhere). We recorded their departure and arrival times and the main subsistence activity in which they were involved. Foods were weighed with Homs spring scales (1, 5, 10, 25, and 50 kilograms) when individuals arrived in camp, and the weights were entered in the data notebook. The scales were zeroed prior to each day of data collection. Foods weighing less than 500 grams were weighed to the nearest 50 grams, and foods weighing between 500 grams and 10 kilograms were weighed to the nearest 100 grams. Foods weighing more than 10 kilograms were often divided and weighed to an accuracy of 100 grams, although they were occasionally weighed as single packages to the nearest 250 grams. Foods above 20 kilograms were either divided and weighed to the nearest 100 grams or were weighed whole to the nearest half kilogram. Nine percent of all food packages were weighed to the nearest 50 grams, 90 percent were weighed to the nearest 100 grams, and 1 percent were weighed to the nearest half kilogram. Since the median package size was 10 kilograms, the median error of measurement was plus or minus 1 percent.

On a few occasions, representative samples of game and wild plant foods were weighed whole and then again after all processing prior to cooking had been completed. These data were gathered in order to estimate edible proportions of resources. Loss in cooking was not estimated but is generally small since the Hiwi boil much of their food and drink the broth.

All members of the study population were weighed once a month with a Harpenden (Holtain Ltd.) beam scale with a long pillar and nondetachable

TABLE 1
Characteristics of the Sample on Food Consumption:
Number of Days and Consumer-Days Sampled

Month/Year (dates)	Number of days sampled	Number of consumer-days sampled	SEASON
January 1988 (8–12, 18–21, 27–31)	14	673	EARLY DRY
February 1988 (1–5, 11, 17, 26, 27)	9	616	LATE DRY
March 1988 (1–4)	4	168	LATE DRY
April 1986 & 1988 (3, 4, 6, 8, 10, 11, 14, 16, 18, 19; 12/1986)	11	761	LATE DRY
May 1988 (2–6, 10, 11, 13–15)	10	389	EARLY WET
July 1987 & 1988 (8/87, 15/88)	2	172	EARLY WET
November 1985 (15–30)	16	1406	LATE WET
December 1985 & 1988 (2–7/85; 14–26, 18, 21/88)	21	450	EARLY DRY
TOTAL	87	4635	

weights. Weights were recorded to the nearest 100 grams. Triceps skinfold thickness and standing height were also measured each month, but those data are not reported here.

Information on the seasonality of conceptions was ascertained in demographic interviews with a bilingual informant who asked women to describe the main food staples at the time of each of their children's births. Our informant, in turn, knew the months of the year when these resources come into season. Due to the high seasonality of tubers, fruits, legumes, turtle eggs, and honey,

TABLE 2
Characteristics of the Sample on Time Spent Foraging per Day:
Number of Individuals and Person-Days Sampled

Month/Year (dates)	Number of individuals		Number of person-days sampled	
	males	females	males	females
January 1988 (8–12, 18–21, 27–31)	31	29	218	179
February 1988 (1–5, 11, 17, 26, 27)	31	29	180	179
March 1988 (1–4)	31	29	52	49
April 1986 & 1988 (3, 4, 6, 8, 10, 11, 14, 16, 18, 19; 12/86)	31	29	248	217
May 1988 (2–6, 10, 11, 13–15)	31	29	118	114
July 1987 & 1988 (8/87, 15/88)	31	29	56	50
November 1985 (15–30)	28	28	417	440
December 1985 & 1988 (2–7/85; 14–26, 18, 21/88)	31	29	146	135
TOTAL	—	—	1435	1363

births could be easily matched to months of the year, and independent verification (using births recorded by local officials or the investigators) showed these estimates to be reliably consistent within a range of one to two months.

Tables 1 and 2 describe the characteristics of the samples on food consumption and time spent foraging per day. These tables show the number of days, consumer-days, individuals, and person-days sampled per month and per season.

Definition of Seasons

Seasonal periods in this study reflect the yearly divisions used by the local criollo and Hiwi populations. They are partially defined by rainfall patterns but

are more reflective of water levels in the rivers, lagoons, and savanna depressions. Rainfall is generally well above 100 millimeters per month between April and November and well under 100 millimeters per month between December and March. No rain at all falls between January and March, and the north wind blows constantly. Local people, however, include April in the dry season because of the low water levels common throughout that month. Dramatic changes in flooding and drying across the year have an important effect upon the availability and distribution of food and resources, ease of transportation to foraging sites, environmental hazards, and many other ecological parameters. Consequently, the early dry season begins when the savanna starts to dry out and vehicles can traverse it successfully (around the first of December). This season is characterized by a dry savanna with river levels several meters below the highest riverbanks of the local area. Most oxbow lakes and savanna depressions hold water through the early dry season and become important sites for intensive fishing as they shrink in size. The late dry season begins in February and is defined by a complete drying of savanna depressions and all but the deepest oxbow lakes along the rivers. It is considerably drier than the early dry season, with rivers reaching levels which may be more than 20 meters below the high-water level.

Rains begin in mid-April, but the early wet season does not start until about May first, when all vehicles leave the area and the dried ponds and swamps again hold water. The water levels of rivers and ponds begin to rise, but the savanna itself still is generally dry. In the late wet season beginning around September, rivers often overflow even the highest riverbanks in the area. The savanna becomes an extensive unending lagoon, and only a few small islands of dry land are available. In this season both human and other terrestial mammal populations are highly concentrated, and travel by dugout, boat, or plane is the only mode of transportation used in the area. By the first part of December, the waters subside to the point that land vehicles can again enter the area, and the cycle begins anew. The year was thus divided into four periods before data were inspected. These periods are (1) early dry—December and January; (2) late dry—February, March, and April; (3) early wet—May, June, July, and August; and (4) late wet—September, October, and November.

A Note on Work Effort

Throughout this paper, "work" or "foraging effort" only refers to time spent foraging away from camp. Data on other important subsistence activities such as food processing and manufacturing are currently under analysis. Preliminary summary statistics indicate that there are important differences between the sexes and across seasons in time spent in these other activities (unpublished data).

THE HIWI DIET

The relationship between the health status of adults and changes in the sexual division of labor across seasons is examined by first describing the main

food staples, their relative caloric contribution to the Hiwi diet, and their differential distribution over the annual cycle. We then investigate the varying contributions of the sexes to food consumption in terms of caloric acquisition and foraging effort and examine the association between these factors, body composition (mainly weights), and female fertility. It is important to emphasize again the the following quantitative descriptions and analyses only include data collected at a large central-place settlement. Analyses of subsistence behavior at temporary bush camps will be presented elsewhere.

The Hiwi exploit a wide variety of animal and wild plant foods in the savanna, gallery forests, rivers, and swamps. The food resources acquired during our study are described in Table 3 and are divided into four major categories: game and fish, wild plant foods, agricultural products, and store-bought foods. This table also lists edible portions and the number of calories per edible kilogram, along with the bibliographic and laboratory sources used to obtain them.

The meat component of the Hiwi diet was primarily derived from six species of mammals (capybara, collared peccary, deer, anteater, armadillo, and feral cattle), numerous species of fish, and three or more species of turtles. In addition, our sample included iguanas and savanna lizards, wild rabbits, and many species of birds.

Capybaras were primarily hunted along riverbanks or in shallow lagoons. Collared peccaries and anteaters, by contrast, were found in the gallery forests, while deer and feral domestic animals were hunted in the savanna–forest edge. Turtles were heavily preyed upon in the late wet season and were killed with either spears or arrows in oxbow lakes along riverbanks. Turtle eggs came into season during January, February, and March and were intensively exploited by tourists, local criollo residents, and the indigenous populations. Although the vast majority of eggs exploited by the Hiwi came from turtles belonging to the genus *Podocnemis*, eggs from other turtles and unidentified species of birds were also acquired.

The Hiwi also gathered five species of roots, a variety of fruits, palm nuts and hearts, a wild legume (*Campsiandra comosa*), and honey produced by various species of bees and, to a lesser extent, wasps.

Agricultural products in the Hiwi diet included plantains, corn, and squash. These staples were grown by some Hiwi families who kept small and widely scattered unproductive fields. Store-bought resources were available at neighboring cattle ranches and at a town approximately 30 kilometers from the Hiwi village, but most store-bought commodities were gifts from either the anthropological team or tourists who come to fish the local rivers and streams. These consisted primarily of inexpensive carbohydrate staples and sweets (rice, noodles, corn flour, and sugar).

Table 4 summarizes the Hiwi diet for the eight months of the year that were sampled. As in Table 3, the resources are divided into four major categories: game and fish, wild plants, agricultural products, and store-bought staples. Because roots were the primary source of carbohydrates, whereas other wild

TABLE 3
Hiwi Food Resources

Scientific name[1]	Description	Calories/ edible kg.	Edible portion[2]	Source[3]	Season
GAME AND FISH:					
Hydrochaeris hydrochaeris	Capybara	1817	.75	D	year round
Milossoma duriventris; Pseudoplastystoma sp.; Hoplias malabariscus; Serrasalmus sp. and others	Fish	960	.75	B	dry season
Caiman cocrodilus	Alligator	1288*	.75	B	dry season
Tayassu tajacu	Collared peccary	1770	.75	A	year round
Odocoelius mazama	Deer	1460	.75	B	year round
Chelus fimbriatus; Podocnemis sp.; Geochelone sp.	Turtles & tortoise	890	.5	B	late wet season
Dasyptus novemcinctus	Armadillo	1540	.75	A&B	early dry season
Iguana iguana; Tupinambis nigropunctatus	Iguana and savanna lizard	1120	.75	B	late wet season
—	Feral domestic cattle	1785**	.75	B	year round

Tamandua tetradactyla	Anteater	1460	.75	D	dry season
Ajaia ajaja; Amazonetta brasiliensis and others	Birds	1700	.75	D	dry season
Sylvilagus fondanus	Rabbit	1590	.75	B	n.a.
—	Bird and turtle eggs	2180	.9	B	turtle eggs-dry season

WILD PLANTS:
Roots:

Dracontium asperum	Small wild potato 'Hero'	1200	.9	D	late wet
Banisteriopsis	Wild root (bitter) 'Oyo'	682	.9	D	late wet
Calathea allonia	Wild root (bitter) 'Hewyna'	682	.9	D	early dry
Cannas edulis	Wild root (sweet) 'Yatsiro'	1200	.9	B	late dry
Dioscorea sp.	Wild root (sweet) 'No'o'	1000	.9	B	early dry

Other plants:

Mangifera indica	Ripe mangos	590	.5	B	late dry/early wet
	Unripe mangos	440			

Table 3—*Continued*

Scientific name[1]	Description	Calories/ edible kg.	Edible portion[2]	Source[3]	Season
Citrus aurantium	Oranges	393	.9	B	late wet
Miscellaneous	Various fruits	599	.9	B	n.a.
Mauritia minor	'Jojjom' fruit	845	.22	D	early wet
Unidentified	'Guaye' fruit	599	.13	D	early wet
Unidentified	Merei fruit	460	.82	B	early wet
Unidentified	Madroña fruit	599	.4	D	early wet
Mauritia minor	Palm nuts 'Yopijicua'	2960	.33	D	late dry
Mauritia minor	Palm heart	595	1.00	A	late dry
Campsiandra comosa	Legume 'Chiga'	4000	.3	E	early wet
HONEY: Unidentified	Honey	2673***	1.00	B	dry season

AGRICULTURAL PRODUCTS:					
Musa sp.	Plantain	1320	.9	B	?
Zea mays	Corn	970	.28	B	?
Cucurbita maxima	Squash	350	.9	B	?
STORE-BOUGHT FOODS:					
—	Rice	3640	1.00	B	dry season
—	Noodles	1107	1.00	B	dry season
—	Sugar	3840	1.00	B	dry season
—	Corn flour	1890	1.00	B	dry season

[1] Faunal species were identified through reference to Sánchez 1981. Floral species identification was provided by Dr. Roberto Lizarralde, Universidad Central de Venezuela, Caracas.

[2] We have only included the edible portions for faunal species used when the animal was weighed whole (i.e., not gutted). All game items weighed already gutted were assumed to have an edible portion of 90%. The edible portion values for some animal prey were measured among the Ache (deer, collared peccary, anteater, capybara, fish) in previous fieldwork (see Hill et al. 1984), while others were measured among the Hiwi (turtles, tortoises, iguanas). The edible portions for vegetable resources were measured at the Hiwi site.

[3] SOURCE A—Analyses of foods acquired by the Ache of Eastern Paraguay conducted by Ford Chemical Laboratory, Salt Lake City, Utah; B—Handbook of Latin American Foods (Leung 1961); C—USDA Handbooks 8 and 456; D—extrapolated from similar items listed in A, B, or C (see Hill et al. 1984: Table 2); E—Sánchez et al. 1987.

*Only caloric values for dried alligator meat were found. Based on a 180 percent increase in caloric content between raw and dried beef, we estimated this value for raw caiman meat (source B).

**Leung (1961) lists 1130 calories per kilogram of very thin edible beef. This seems to be a very low estimate given the higher caloric values we have found for wild animals. Consequently, here we use the mean calories per kilogram reported for medium fat and very thin in the same table.

***Measured in liters.

TABLE 4
The Hiwi Diet
Months Sampled: November–May and July; Sampling Period: 1985–88

Resource name (cals/kg)	Amount (kgs)*	Total calories[1]	Mean daily per Capita consumption of calories[2]	Percent of the diet
GAME AND FISH				
Feral domestic cattle (1785)	1,350	2,409,750	520	
Capybara (1817)	730	1,326,410	286	
Fish (960)	1,035	993,600	214	
Caiman (1288)	392	504,896	109	
Collared peccary (1770)	163	352,080	76	
Deer (1460)	136	198,560	43	
Turtles (890)	185	164,650	36	
Armadillo (1720)	91	156,520	34	
Iguana/savanna lizard (1120)	97	108,640	24	
Anteater (1460)	59	86,140	19	
Turtle and bird eggs (2180)	48	104,640	22	
Bird (1700)	22	40,800	8	
Rabbit (1700)	2	3,400	1	
TOTAL GAME AND FISH	4,310	6,450,086	**1,392**	**68%**

VEGETABLES:					
'Hero' (1200)	1,011	1,213,200	262		
'Oyo' (682)	522	356,004	77	**ROOTS**	
'Hewyna' (682)	314	214,148	46		
'Yatsiro' (1200)	20	24,000	5		
'No'o' (1200)	7	8,400	2		
Total roots:	1,874	1,815,752	**392**	**19%**	
Ripe mangos (590)	537	316,830	68		
Green mangos (590)	112	66,080	11		
Palm nuts (2960)	30	88,800	19	**OTHER**	
'Chiga' (4000)	12	49,640	10		
Oranges (393)	24	9,432	2	**VEGETABLE**	
Mathenouto, uthuburu, umbobu (599)	14	8,386	2		
'Jojjom' fruit (599)	13	7,787	2		
'Guaye' fruit (599)	8	4,792	1		
Merei fruit (460)	7	3,220	1		
Palm heart (595)	7	4,165	1		
Waco fruit (599)	2	1,198	—		
HONEY (2673)	86	229,824	48		
Total other vegetable:	852	790,154	**165**	**8%**	
TOTAL VEGETABLE:	2,859	2,609,460	**557**	**27%**	
TOTAL ALL WILD FOODS:	7,169	8,658,752	**1,949**	**95%**	

Table 4—*Continued*

Resource name (cals/kg)	Amount (kgs)*	Total calories[1]	Mean daily per Capita consumption of calories[2]	Percent of the diet
AGRICULTURE:				
Plantain (1320)	31	40,920	8	
Corn (970)	8	7,760	2	
Auyama (350)	9	3,150	1	
TOTAL AGRICULTURE:	48	51,830	**11**	**1%**
STORE-BOUGHT FOOD AND GIFTS FROM OUTSIDERS:				
Beef (1785)	124	221,340	47	
Rice (3640)	36	131,040	28	
Spaghetti (1107)	24	26,568	6	
Sugar (3840)	1	3,840	1	
Corn flour (1890)	1	1,890	i	
STORE-BOUGHT TOTAL:	186	300,972	**83**	**4%**
TOTAL MEAN PER CAPITA OF CALORIES CONSUMPTION			**2,043 cals**	

[1]Kilograms × number of calories per EDIBLE kilogram.
[2]There were a total number of *4635 consumer-days* for the entire sample period. Consumers were defined as all individuals over the age of 3.5 years.
*Edible portion only.

plants contributed comparatively less to food intake, the wild plant foods category is in turn divided into roots and other plant foods.

Major categories are ranked according to their relative caloric contribution to the diet (from highest to lowest), and resources within each category are ranked in the same way. The number of edible kilograms of each resource acquired during the entire sample period is listed along with the total calories calculated for each resource using the values for calories/edible kilogram shown on Table 3. The total number of edible kilograms for each food item brought into camp was multiplied by the number of calories per kilogram listed in Table 3. These totals in combination with the sum of the number of consumers present in camp for each day sampled allowed us to estimate the number of calories consumed per person-day by the average Hiwi individual for the entire sample period (3,635 consumer-days). It is important to note that this mean is weighted by sample day rather than weighted seasonally. "Consumers" were defined in this study as individuals over the age of 3.5 years.[6]

Table 4 shows that meat was an important source of food energy in the Hiwi diet during the period that was sampled. It was probably the main contributor of protein and lipids as well. Sixty-eight percent of the total caloric intake came from game and feral domestic animals. Capybara, feral animals,[7] and fish each provided 200 calories or more per consumer-day. These were followed in importance by caiman, peccary, deer, turtles, armadillo, iguana, and anteater, each providing more than 50 calories per consumer-day, and finally, by turtle eggs, birds, and rabbit, which each provided fewer than 50 calories per consumer-day. A total of 1,392 calories per consumer-day was derived from meat. This amounts to a mean daily per capita consumption of 930 grams of edible meat.

Collected foods accounted for 27 percent of the daily caloric intake of Hiwi foragers (557 calories). Roots provided the highest percentage of the plant food calories acquired (19 percent, or 392 calories), with "hero" root, a small wild potato, being the most important (mean daily per capita consumption = 262 calories). Less food energy per consumer-day was derived from the "oyo," "hewyna," "yatsiro," and "no'o" roots (<80 calories each). Only 8 percent of mean daily per capita consumption of calories came from other plant resources (165 calories per day). Ripe mangoes provided more food energy to the Hiwi than any other fruit, but this was still less than 100 calories of the mean daily per capita consumption. All other fruits were of minor importance (<20 calories each per consumer-day). Finally, honey (48 calories per consumer-day) accounted for about 2 percent of the daily energy consumption of Hiwi foragers.

The results show that wild plant and animal foods were the source of most of the Hiwi's food energy during our study. The mean daily per capita consumption of these resources was 1,949 calories per consumer-day, or 95 percent of the total. The remaining 5 percent of food energy can be attributed to store-bought foods and agricultural products, with store-bought resources providing more of the daily caloric per capita consumption (4 percent, 83
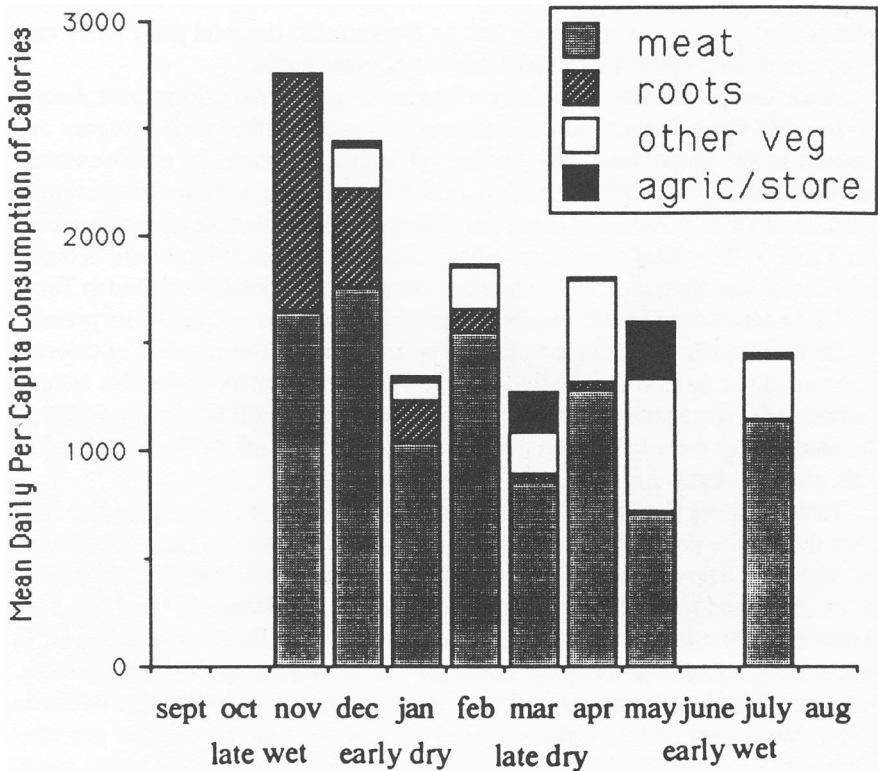
Figure 3a. Mean Daily per Capita Consumption of Calories among
Hiwi Foragers across Months

calories) than agricultural products (1 percent, 11 calories). The sum total of
the calories consumed per person-day among the Hiwi during our sample period
was *only 2,043 calories.*

  These analyses of the diet suggest that the Hiwi population we studied was
essentially a foraging population who depended on hunting and gathering for
most of their food energy during our study. Most importantly, game, rather
than plant foods, appears to have been their main source of energy, as well
as of protein and lipids.

Seasonal Variation in the Diet

  Figures 3a and 3b illustrate changes in the mean daily per capita consumption
among Hiwi foragers across months and seasons of the year respectively. In
order to calculate mean daily per capita consumption for these analyses, we
summed the number of calories acquired on a given day and divided the total
by the number of consumers present in camp on that day. Each of these daily
means was then summed and divided by the total number of days in a seasonal
sample in order to arrive at the mean daily per capita consumption of calories
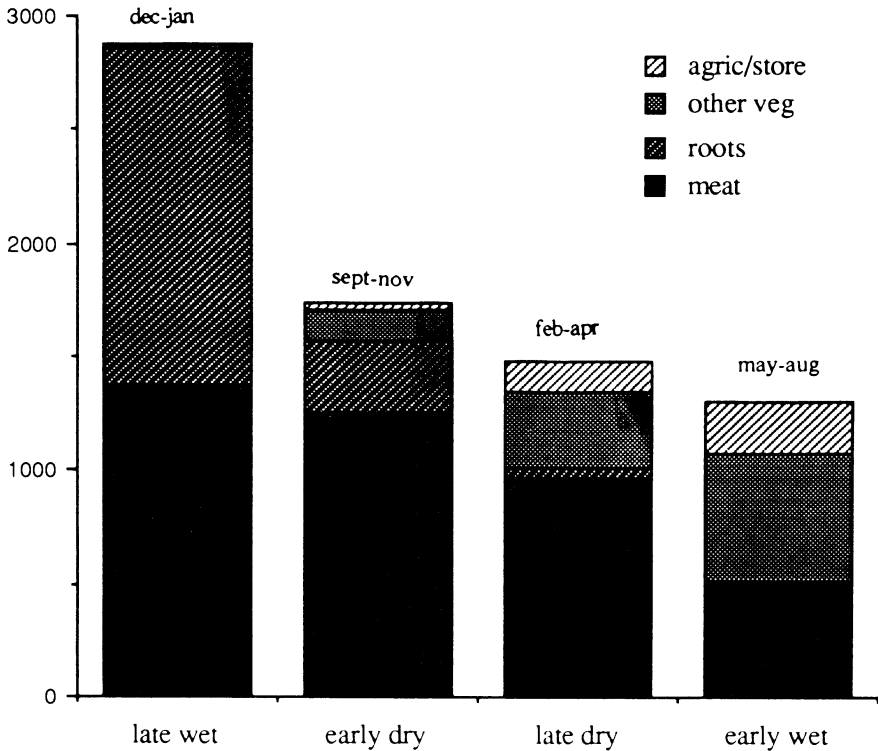for that season.

Figure 3b. Mean Daily per Capita Consumption of Calories among
Hiwi Foragers across Seasons

In order to evaluate whether our measured mean differences in the daily
mean per capita consumption of calories across seasons were likely to be real
or due to sample error and random fluctuation, we ran two-tailed one-way
ANOVAs (the samples were normally distributed). The results are presented
in Table 5. This table includes the daily mean per capita consumption for each
season across the top rows corresponding to each food type and the mean
difference in mean daily consumption of calories between pairs of seasons in
the boxes beneath. Within- and between-group analyses of variance of mean
daily per capita consumption across seasons and according to resource category
do not allow us to reject the hypothesis that mean seasonal differences in total
calories derived from all foods were due to sample error during our sample
period (p = .123, two-tailed). Seasonal differences in consumption of meat
and agricultural products were also shown not to be statistically significant. It
is nevertheless interesting to note that the late wet season shows a higher
mean per capita consumption (>2,500 calories) than other seasons (mean
<2,000) (Table 5), since Hiwi informants claim that this is the season of highest
food availability.

Meat consumption did not seem to contribute to seasonal differences in total

TABLE 5
Mean Difference in Daily Mean Per Capita Consumption of Calories across Seasons

SEASONS	EARLY DRY	LATE DRY	EARLY WET	LATE WET	
	ALL FOOD				ANOVA
	mean = 1735	mean = 1448	mean = 1350	mean = 2756	F-test = 1.99
	SE = 282	SE = 286	SE = 220	SE = 473	p = .123
	n = 26	n = 24	n = 12	n = 15	
EARLY DRY		− 297	− 460	1026	
LATE DRY			− 180	1200	
EARLY WET				1460	
	MEAT				ANOVA
	mean = 1247	mean = 957	mean = 509	mean = 1378	F-test = 1.779
	SE = 234	SE = 151	SE = 201	SE = 202	p = .1583
EARLY DRY		− 290	− 739	− 278	
LATE DRY			− 449	− 120	
EARLY WET				505	
	ROOTS				ANOVA
	mean = 322	mean = 58	mean = 5	mean = 1478	F-test = 8.439
	SE = 129	SE = 24	SE = 17	SE = 331	p = .0001
EARLY DRY		− 265	− 317	1074	
LATE DRY			− 53	1380	
EARLY WET				1431	
	OTHER VEGETABLE				ANOVA
	mean = 135	mean = 325	mean = 559	mean = 15	F-test = 8.524
	SE = 79	SE = 345	SE = 129	SE = 13	p = .0001
EARLY DRY		189	502	− 122	
n = 26					
LATE DRY			313	311	
n = 24					
EARLY WET				− 624	
n = 12					
	AGRICULTURE				ANOVA
	mean = 17	mean = 13	mean = 0	mean = 6	F-test = .781
	SE = 10	SE = 6		SE = 23	p = .5082
EARLY DRY		− 4	− 17	− 11	
LATE DRY			− 13	− 17	
EARLY WET				6	
	STORE-BOUGHT				ANOVA
	mean = 15	mean = 125	mean = 229	mean = 2	F-test = 2.902
	SE = 11	SE = 61	SE = 126	SE = 2	p = .0407
EARLY DRY		110	214	− 14	
LATE DRY			105	− 123	
EARLY WET				− 228	

energy consumption even though the composition of animal species in the Hiwi diet varied dramatically across the year. For example, during the dry season months, the Hiwi consumed twice the amount of fish that they consumed in the wet period (p = .048, two-tailed t-test), and yet this difference is not reflected in the overall caloric intake of energy derived from meat. This occurs because the Hiwi acquired other animal species such as turtles and capybaras during the wet season.

In contrast to meat, roots and other wild plant foods were highly seasonal food staples (p = .0001, two-tailed ANOVA; Table 5). Calories derived from roots peaked during the late wet season, and those derived from other wild plant foods peaked during the early wet season. During the wet season, then, the Hiwi consumed larger quantities of carbohydrate foods than in the dry season.

Among the less important categories, store-bought foods showed significant high seasonal variance, while agricultural products did not. Even though the Hiwi ate store-bought foods in small quantities throughout the year (<300 cals/consumer-day), they tended to consume significantly more of these foods during the early wet season than at other times, primarily because of the presence of local tourists in the region in May (p = .0407, two-tailed ANOVA). The contribution of agricultural foods was too small to adequately detect significant seasonal differences.

The above analyses allow us to divide the annual cycle according to the main plant foods that are acquired across seasons. In our sample, the seasons can be characterized as the root season (late wet), the mango/chiga season (early wet), and a long dry season of scarce plant resources. This variation in the consumption of plant foods may have important biological implications. Consequently, in addition to the rainfall criteria used above, labels that reflect this variability will also be used in the analyses of sex differences in subsistence strategies, nutritional status, and fertility across seasons.

THE SEXUAL DIVISION OF LABOR

The annual food consumption cycle is the product of sex differences in subsistence strategies. Men and women acquired different types of foods, with different caloric values and in different quantities, as seasons changed. Sex differences in foraging effort were also unevenly distributed in time. In the following analyses only observations on men and women between twenty and fifty-five years of age are included.

Food Acquisition

Figures 4a and 4b show the monthly and seasonal variation in the number of calories that were acquired per day by Hiwi men and women. The late wet peak in Figure 4b suggests that the apparently more plentiful diet of the late wet season was due to greater caloric acquisition by Hiwi women during this time relative to other seasons.

We disaggregated the data on women's caloric acquisition and foraging effort (see below) into two groups: nonnursing and postreproductive women, and nursing and pregnant women (see Tables 6–9, below). We did this because we are interested in determining whether females who are in a reproductively costly state (nursing and pregnant women) experience greater health costs as a result of increases in work effort or low food consumption than do women
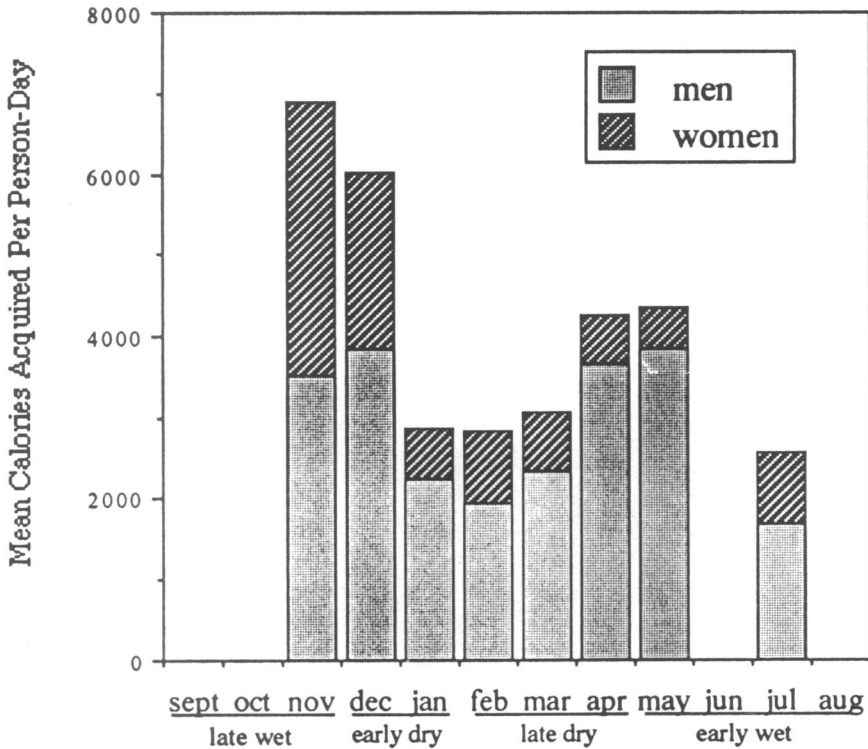
Figure 4a. Mean Number of Calories Acquired per Person-Day among Hiwi Men and
Women across Months

who are experiencing relatively low reproductive costs (nonnursing and post-
reproductive women). We have lumped our observations on postreproductive
and nonnursing women because preliminary analyses showed that changes in
their foraging behavior were very similar across seasons. This was also true
of nursing and pregnant women (Hurtado and Hill 1990).

"Postreproductive" and "nonnursing" women include those individuals who
had not experienced a pregnancy over the past five years and whom we
estimated to be over forty-five years of age and those women of reproductive
age who were not lactating over the period sampled. "Nursing" and "pregnant"
women are individuals who were lactating during the month when behavioral
observations took place or who were pregnant.

Sex Differences. The average Hiwi man produced significantly more calories
per person-day than did the average Hiwi woman in all seasons except for the
late wet season when roots were in the diet (Table 6). In the dry season, men
acquired just fewer than 3,000 calories per person-day, while in the wet season,
they acquired over 3,000 calories. The women, on the other hand, produced
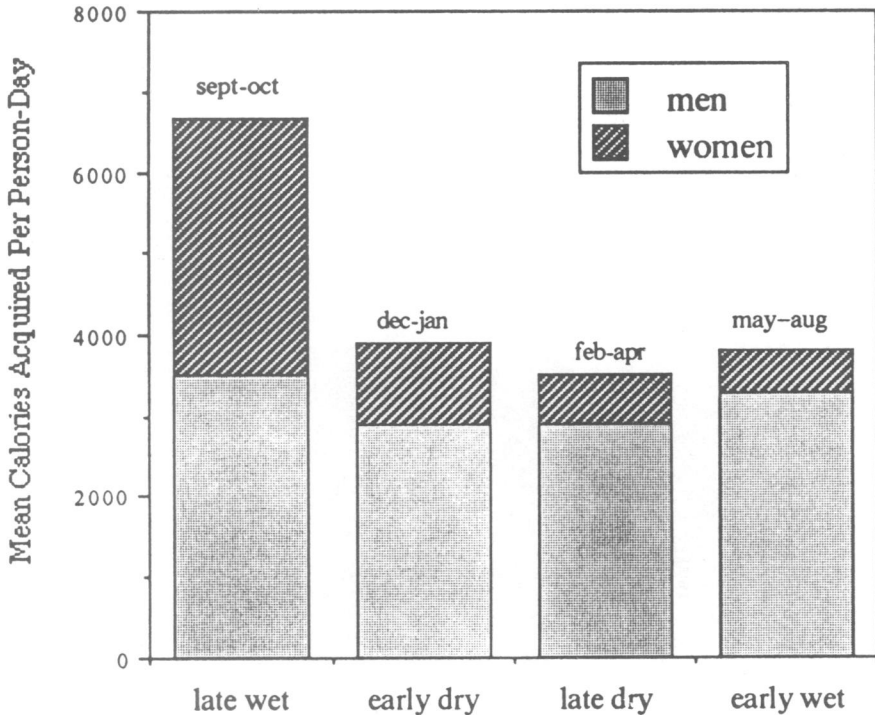fewer than 1,500 calories per person-day (range = 420–1,171) during the dry

Figure 4b. Mean Number of Calories Acquired per Day among Hiwi Men and
Women across Seasons

and early wet seasons. In the late wet season, however, they acquired a mean
of over 3,000 calories per woman-day (Table 6).

Seasonal Differences. Table 7 shows seasonal differences in the number of
calories that men and women acquired from the point of view of each sex.
Because the data are normally distributed, we used one-way ANOVAs to test
for significance levels. This table includes the mean number of calories acquired
per person-day for each season across the top rows corresponding to each
sex and the mean difference in the mean number of calories acquired per
person-day between pairs of seasons in the boxes beneath. While Hiwi men's
caloric acquisition was constant throughout the year ($p = .6890$, two-tailed),
women's contribution was highly variable ($p = .0215$ and $.0012$, two-tailed)
for nonnursing and postreproductive women and for nursing and pregnant
women respectively.

Although men's caloric acquisition appears to have been constant across
seasons, Hiwi men acquired significantly more fish in the dry season than in
the wet season (see above). In addition, during the mango/chiga season (early
wet season), Hiwi men's subsistence behavior deviated from the typical sexual
division of labor pattern: the men did more than half the fruit gathering during

TABLE 6
Sexual Division of Labor among Hiwi Hunter-Gatherers:
Mean Number of Calories Acquired per Person-Day*

		WOMEN				
SEASON	**MEN**	**NONNURSING AND POSTREPRODUCTIVE**	**p=**	**NURSING AND PREGNANT**	**p=**	**SEASONS**
LATE WET	mean = 3505 SE = 502 n = 395	mean = 3382 SE = 296 n = 192	>.05	mean = 2960 SE = 281 n = 123	>.05	roots
EARLY DRY	mean = 2893 SE = 401 n = 502	mean = 1171 SE = 150 n = 184	<.05	mean = 820 SE = 80 n = 107	<.05	
LATE DRY	mean = 2887 SE = 371 n = 614	mean = 724 SE = 117 n = 241	<.05	mean = 502 SE = 101 n = 129	<.05	
EARLY WET	mean = 3288 SE = 559 n = 221	mean = 626 SE = 144 n = 95	<.05	mean = 420 SE = 200 n = 50	<.05	mango/chiga

*p values are the results of two-tailed t-tests comparing men's mean kilocalories acquired per person-day to those acquired by women of different reproductive statuses.

TABLE 7
Mean Differences in Calories Acquired per Day among Hiwi Adults

SEASONS	ROOTS			MANGO/CHIGA	ANOVA
	LATE WET	EARLY DRY	LATE DRY	EARLY WET	
	MEN				
	mean = 3505 SE = 502 n = 395	mean = 2893 SE = 401 n = 502	mean = 2887 SE = 371 n = 614	mean = 3288 SE = 559 n = 221	p(2-tailed) = .6890
LATE WET		−612	−618	−217	
EARLY DRY			−6	395	
LATE DRY				401	
	POSTREPRODUCTIVE AND NONNURSING WOMEN				
	mean = 3382 SE = 296 n = 192	mean = 1171 SE = 150 n = 184	mean = 724 SE = 117 n = 241	mean = 626 SE = 144 n = 95	p(2-tailed) = .0215
LATE WET		−2211	−2658	−2756	
EARLY DRY			−447	545	
LATE DRY				−98	
	NURSING AND PREGNANT WOMEN				
	mean = 2960 SE = 281 n = 123	mean = 820 SE = 80 n = 107	mean = 502 SE = 101 n = 129	mean = 420 SE = 200 n = 50	p(2-tailed) = .0012
LATE WET		−2140	−2458	−2540	
EARLY DRY			−318	−400	
LATE DRY				−82	

this season. Hiwi men acquired 65 percent of the total kilograms of mango brought to camp. The average man acquired 602 mango calories per person-day, while the average woman acquired only 378. During the remainder of the year, however, the sexual division of labor is marked: men rarely dug roots ($n = 2$ man-days) or gathered other plant foods ($n = 9$ man-days). Although Hiwi women often accompanied their husbands on hunting and fishing expeditions, they rarely engaged in hunting or fishing and only acquired 12 kilograms of meat (mainly fish and land turtles) over the entire sample period.

Foraging Effort

Figure 5 shows the mean number of hours spent foraging per day across seasons by men and by women of different reproductive statuses. In this section "work," "work effort," "work output," and "foraging" are invariably used to mean time spent hunting/fishing and/or gathering.

The first striking feature of time allocation among the Hiwi is the relatively few hours that they spent out of camp foraging per day (<3 hours in any season) when compared to the economic behaviors of other populations (Minge-Klevana 1980; but see Hames 1989:64). We have made eight hours the maximum value on the y axis to illustrate this point. Second, changes in foraging effort across the year by either sex were slight and within one hour's range. Lastly, the differences between the sexes in time spent foraging are not very high in absolute terms mainly because the Hiwi spent few hours per day foraging. The highest mean difference between men and women in number of hours spent working per day is only 1.3 hours (compare nursing women to men in Table 8).

Sex Differences. Despite these low absolute differences in work effort, Figure 5 and Table 8 show some significant trends in work effort differences between men and women. First, in the late wet (root) interval, *all women, regardless of reproductive status, spent significantly more hours per day foraging than did men.* This difference extends into the early dry season when some roots continued to be acquired by the women. However, only postreproductive and nonnursing women spent significantly longer hours foraging than did the men in the early dry season. Second, during the early wet (mango) season, all women, regardless of reproductive status, spent significantly fewer hours foraging than did men. Statistical analyses suggest that in the late dry season, men and women spent similar amounts of time hunting and gathering (Table 8).

Seasonal Differences. Another way to study the sexual division of labor is to look at the temporal distribution of foraging effort from the point of view of each sex. Table 9 describes this distribution and the significance levels of behavioral differences between seasons. One-way ANOVAs were used to analyze this normally distributed data set. The table includes the mean number of hours spent foraging per person-day for each season across the top rows corresponding to each sex and reproductive status and the difference in the
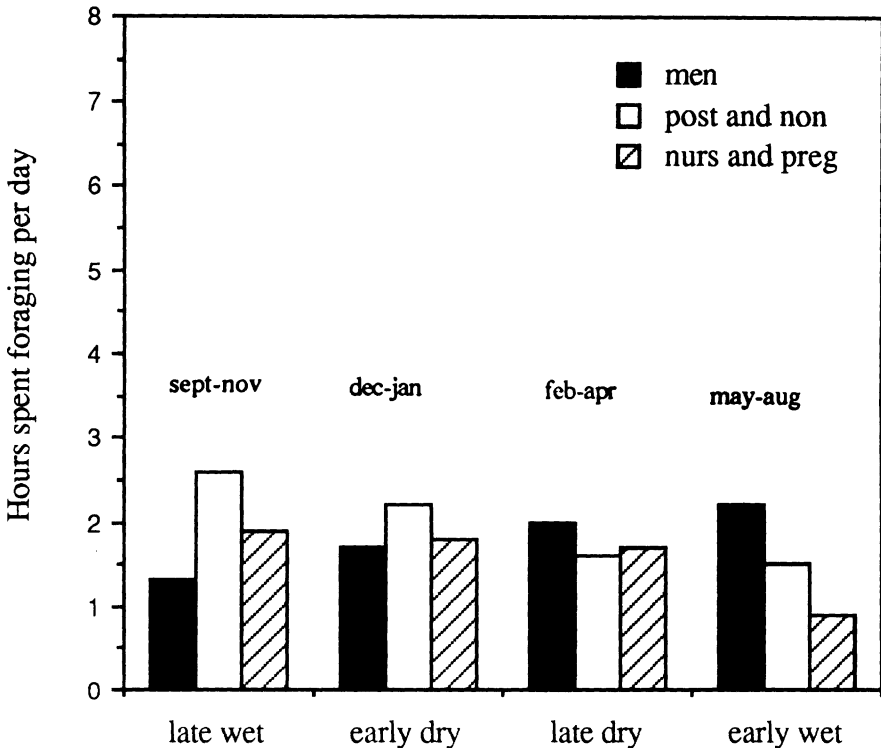
Figure 5. Mean Number of Hours Spent Foraging per Day by Hiwi Men and Women of Different Reproductive Statuses across Seasons

mean number of hours spent foraging per person-day between pairs of seasons in the boxes beneath.

Hiwi men spent fewer hours foraging per day in the late wet (root) season than in any other season of the year (Table 8). The primary foraging activities of Hiwi men during this season were hunting and some fishing; they rarely foraged for plant foods. It is interesting that even though Hiwi men significantly reduced foraging effort during the root season, they continued to produce as many calories derived from meat as in other seasons of the year.

Men's fluctuations in time spent foraging appear to have been due to *increases and decreases in time spent gathering rather than to changes in time spent hunting.* Men allocated the extra time they spent foraging in the late dry season to honey and egg gathering (0.7 hours increment per day from the late wet season mean) and to fruit gathering in the early wet season (0.9 hours increment per day from the late wet season mean; $n = 483$ and 180 man-days respectively) (see Table 9). The men did not increase time spent hunting or fishing during these seasons. Our sample also included two old men who showed the same change in time spent foraging that we report for men twenty to fifty-five years of age. During the root seasons (late wet and early dry), these men spent a mean of 0.2 and 0.6 hours foraging per day, while during the late dry and early

TABLE 8

Sexual Division of Labor among Hiwi Hunter-Gatherers:
Mean Daily Number of Hours Spent Foraging

	MEN	WOMEN		
SEASONS		NURSING AND PREGNANT	NONNURSING AND POSTREPRODUCTIVE	
LATE WET roots	mean = 1.3 SE = 0.9 n = 372	mean = 1.9* SE = 0.3 n = 138	mean = 2.6* SE = 0.2 n = 192	
EARLY DRY	mean = 1.7 SE = 0.13 n = 421	mean = 1.8 SE = 0.24 n = 135	mean = 2.2* SE = 0.34 n = 184	
LATE DRY	mean = 2.0 SE = 0.11 n = 483	mean = 1.7 SE = 0.23 n = 154	mean = 1.6 SE = 0.18 n = 241	
EARLY WET mango/chiga	mean = 2.2 SE = 0.24 n = 180	mean = 0.91* SE = 0.4 n = 62	mean = 1.5* SE = 0.3 n = 95	

Unpaired T-test, 2-tailed comparison between men and women
* = <.05

TABLE 9
Mean Differences in Hours Spent Foraging per Day among Hiwi Adults

SEASONS	ROOT			MANGO/CHIGA	ANOVA
	LATE WET	EARLY DRY	LATE DRY	EARLY WET	
	MEN				*ANOVA*
	mean = 1.3	mean = 1.7	mean = 2	mean = 2.2	F-test = 7.892
	SE = 0.9	SE = 0.13	SE = 0.11	SE = 0.24	p = .0001
	n = 372	n = 421	n = 483	n = 180	
LATE WET		0.4	0.7	0.9	
EARLY DRY			0.3	0.5	
LATE DRY				0.2	
	POSTREPRODUCTIVE AND NONNURSING WOMEN				*ANOVA*
	mean = 2.6	mean = 2.2	mean = 1.6	mean = 1.5	F-test = 5.038
	SE = 0.2	SE = 0.34	SE = 0.18	SE = 0.3	p = .0018
	n = 192	n = 184	n = 241	n = 95	
LATE WET		−0.4	−0.18	−1.1	
EARLY DRY			−0.6	−0.7	
LATE DRY				−0.1	
	NURSING AND PREGNANT WOMEN				*ANOVA*
	mean = 1.9	mean = 1.8	mean = 1.7	mean = .91	F-test = 1.55
	SE = 0.3	SE = 0.24	SE = 0.23	SE = 0.4	p = .2006
	n = 138	n = 107	n = 154	n = 62	
LATE WET		−0.1	−0.2	−1	
EARLY DRY			−0.1	−0.9	
LATE DRY				−0.8	

wet, they spent 1.8 and 1.5 hours foraging per day (n = 56, 52, 40, and 16 person-days respectively).

Among the women who are less constrained by reproduction (nonnursing and postreproductive women), the seasonality of time allocation, on the other hand, appears to have been the exact opposite of that described for Hiwi men. Postreproductive and nonnursing women spent more hours per day foraging during the late wet (root) season than at any other season of the year (p = .0018, two-tailed). Among the women who are directly constrained by reproduction (nursing and pregnant women), work effort levels showed no statistically significant changes throughout the year (p = .2006, two-tailed), even though in the early wet season they allocated fewer hours to food acquisition relative to other seasons (<1 hour per day).

In summary, caloric consumption among Hiwi foragers is the outcome of within-sex and between-sex differences in decisions concerning what foods to acquire and how long to forage. The wet season diet shows a more even mix of vegetable and meat resources due to an increase in the amount of time that men allocated to gathering plant foods in the mango/chiga (early wet) season and an increase in the amount of time that women spent digging roots in the late wet season. Men produced more food than women in all seasons except the late wet (root) season. Men foraged less during the late wet season, but their total caloric acquisition did not vary throughout the year. Women worked more than men during the late wet (root) season but less than men in the early wet season. Women also provided more food energy during the late wet (root) season when they foraged longer. Nursing and pregnant women worked less and acquired less food than women who were not pregnant or lactating. They also appeared to have maintained a less seasonally variable foraging pattern than other adults.

BODY WEIGHT AND FERTILITY CONSEQUENCES OF DIFFERENCES IN FORAGING EFFORT ACROSS SEASONS

Body Weight

Figures 6a and b and Table 10 show weight changes among Hiwi men and among women of different reproductive statuses. The same definitions and criteria used above apply in our analyses of nutritional status. Pregnant women, however, are excluded from the analyses of seasonal fluctuations in women's weights.

Paired t-tests show that the men reached their highest weights in the late wet season (p = <.05, two-tailed) (Table 10). Between the late dry and late wet season, men gained 3.3 percent of their yearly mean body weight (57.8 kilograms). Figure 6a shows that Hiwi men began to gain weight in the second half of the late dry season and continued to gain weight during the early wet (mango/chiga) season. Men started to lose weight in the early dry season and reached their lowest weights at the beginning of the late dry season. Men's highest body weights coincided with the time of the year when caloric con-
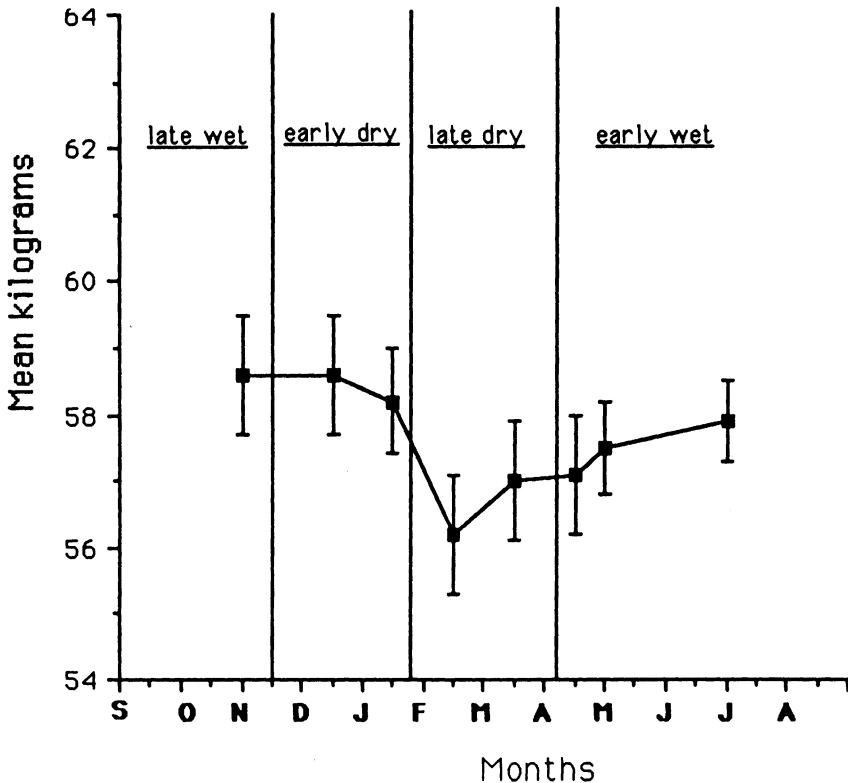
Figure 6a. Mean Body Weight of Hiwi Men across Months and Grouped by Season

sumption may have been the highest (the late wet, root season) and when the men spent fewest hours foraging. Weight loss occurred primarily during the dry season months when the men increased time spent foraging and food consumption appears to decrease. These analyses suggest that the dry season is characterized by a less favorable energy balance for Hiwi men than the wet season.

Postreproductive and nonnursing women, in contrast, attained their highest body weights in the early wet (mango/chiga) season (see Figure 6b). Between the late dry and the early wet season, these women gained 3.7 percent of their yearly mean body weight (48.2 kilograms). By the end of the late wet season, these women had lost weight, and they maintained a constant level until the beginning of the late dry season. As was the case for the men, postreproductive and nonnursing women also lost weight in the late dry season. The results show that postreproductive and nonnursing women attained their highest body weights during the season of the year when they allocated fewer hours to foraging (the early wet season). This is also the season of the year when the Hiwi men did more than half the plant food gathering. Interestingly, Hiwi men and women each appear to have gained weight during the periods
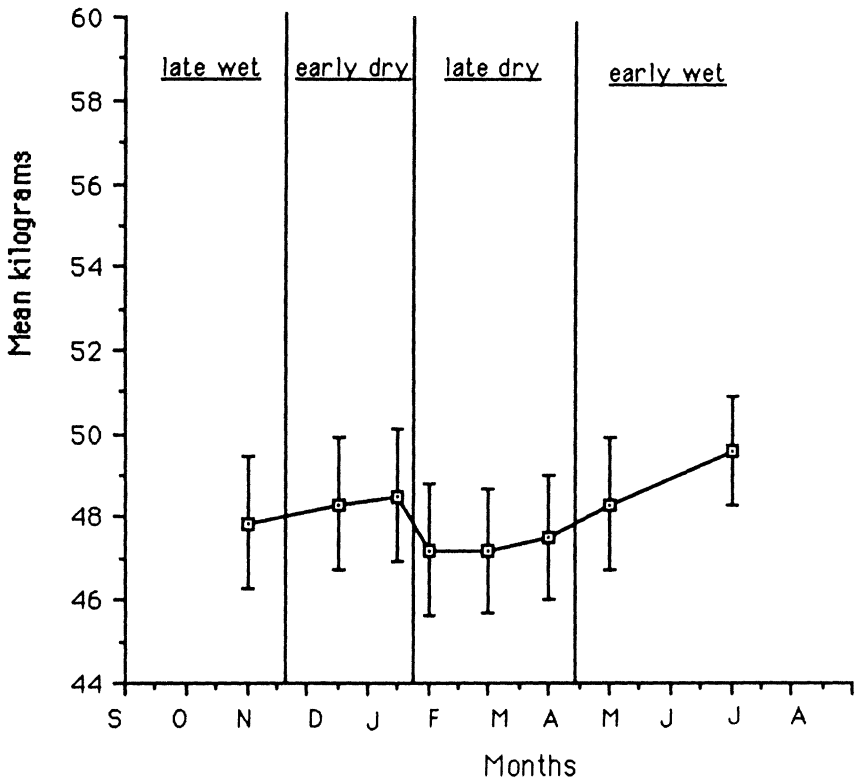
Figure 6b. Mean Body Weight of Hiwi Postreproductive and Nonnursing Women
across Months and Grouped by Season

of the year when the other sex did most of the wild plant food acquisition.
Postreproductive and nonnursing women lost weight during the period that
appears to be the most plentiful time of the year (the late wet, root season).
This is probably due to the increase in time they spent foraging as well as to
an increase in the energetic costs associated with root collecting: digging tubers
is more energy expensive than gathering fruits.

Although our sample is quite small, the data suggest that nursing women
showed patterns of weight change that are similar to those of other Hiwi
women. Nursing women also attained their highest body weights in the early
wet (mango/chiga) season. Between the early dry and late wet seasons, these
women gained 5.1 percent of their yearly mean body weight (48.7 kilograms).
By the end of the late wet season, nursing mothers had lost weight, and they
reached their lowest weights during the first month of the early dry season.

Thus men achieved peak weights during the late wet (root) season, but all
women lost weight during this time. Women in contrast achieved peak weights
during the early wet (mango/chiga) season. All adults except lactating women
showed their lowest body weights in the late dry season.

TABLE 10
Mean Weight Differences (in Kilograms) across Seasons
Paired T-Tests

MEN

SEASONS	LATE WET	EARLY DRY	LATE DRY	EARLY WET
	mean = 58.7 SE = 1.0 n = 18	mean = 58.1 SE = 0.6 n = 26	mean = 56.8 SE = 0.5 n = 24	mean = 57.7 SE = .5 n = 24
LATE WET		−0.6 n = 18 **p = .0027**	−1.9 n = 17 **p = .0001**	−1 n = 18 **p = .0639**
EARLY DRY			−1.3 n = 22 **p = .0001**	−1.5 n = 23 p = .142
LATE DRY				0.9 n = 24 p = .7749

POSTREPRODUCTIVE AND NONNURSING WOMEN

SEASONS	LATE WET	EARLY DRY	LATE DRY	EARLY WET
	mean = 47.9 SE = 1.6 n = 12	mean = 48.3 SE = 1.5 n = 13	mean = 47.4 SE = 1.5 n = 14	mean = 49.2 SE = 1.4 n = 15
LATE WET		0.4 n = 9 p = .2665	−0.5 n = 10 p = .1698	1.3 n = 11 p = .8404
EARLY DRY			−0.9 n = 12 p = .1017	0.9 n = 12 **p = .0402**
LATE DRY				1.8 n = 13 **p = .0006**

NURSING WOMEN

SEASONS	LATE WET	EARLY DRY	LATE DRY	EARLY WET
	mean = 49.3 SE = 1.2 n = 3	mean = 47.5 SE = 1.8 n = 4	mean = 48.1 SE = 2.1 n = 5	mean = 50 SE = 1.8 n = 5
LATE WET		−1.8 n = 2 p = .4472	0.04 n = 2 p = .8764	0.7 n = 2 p = .9646
EARLY DRY			2.2 n = 3 p = .4559	2.5 n = 3 **p = .0334**
LATE DRY				1.9 n = 4 p = .5426

n = number of individuals.
Multiple measurements were made on most individuals in each season.

Fertility

Through reproductive interviews with women and direct observation, we are able to estimate female fertility rates by season. All Hiwi women accurately and consistently identified the season of birth for their children by reporting the resources that were eaten, the rainfall patterns, and the level of flooding at the time each child was born. For individuals born after 1968, the exact birth date is usually known. Because some seasons have more months than others, we standardized female fertility data by calculating the monthly rate of conceptions reported per season. Pregnancies were tabulated by calculating nine months back from the reported month of birth. Consequently, our sample represents only conceptions that terminated in live births. In this sample, we only included data on individuals born between approximately 1950 and 1988.

Hiwi women showed fewer conceptions per month during the early dry season than in other seasons of the year (Figure 7) (chi-square = 28.9, p = .001, n = 122 births reported by 24 women). This finding is not surprising, as birth seasonality has been found in almost every human population where it has been carefully investigated (Leslie and Fry 1989). However, because we also monitored food intake, work effort, and weight changes across the year, we are able to explore the possibility that one or more of these factors account for some of the observed seasonal variation in fertility.

Studies of the physiological mechanisms of fertility variation have often suggested that food intake and work effort play an important role in affecting the probability of conception. Two common proposals are either that current nutritional intake/energy balance affects fertility or that ongoing changes in nutritional intake/energy balance might affect fertility (see Ellison 1989 for a review). We therefore performed two sets of simple regressions with mean monthly fertility rate as the dependent variable. In the first set of three regressions, the independent variables used were mean daily caloric intake, hours worked, or body weight, all calculated by season for reproductive-age women (those at risk of pregnancy). In the second set, the *change* in each parameter (the value recorded in the current season minus the value from the previous season) was used as an independent variable. This allowed us to determine whether periods of gaining or losing weight, increasing or decreasing food intake, or changing work effort were correlated with variations in fertility rates.

Interestingly, female work effort, caloric consumption, and weight in a given season showed little or no association with fertility in that season. Differences in female weight and work effort between a season and the previous season also failed to correlate strongly with fertility rates. However, the difference in mean daily caloric consumption between a season and the previous season was a good predictor of the fertility rate (F-test = 10.5, r^2 = .84, p = .0837) but was not statistically significant with only four data points (the mean monthly fertility rate for each of the four seasons). This test, however, is not the best measure of changes in nutritional status or overall energy balance, since only food intake (not energy expenditure) is incorporated into the independent
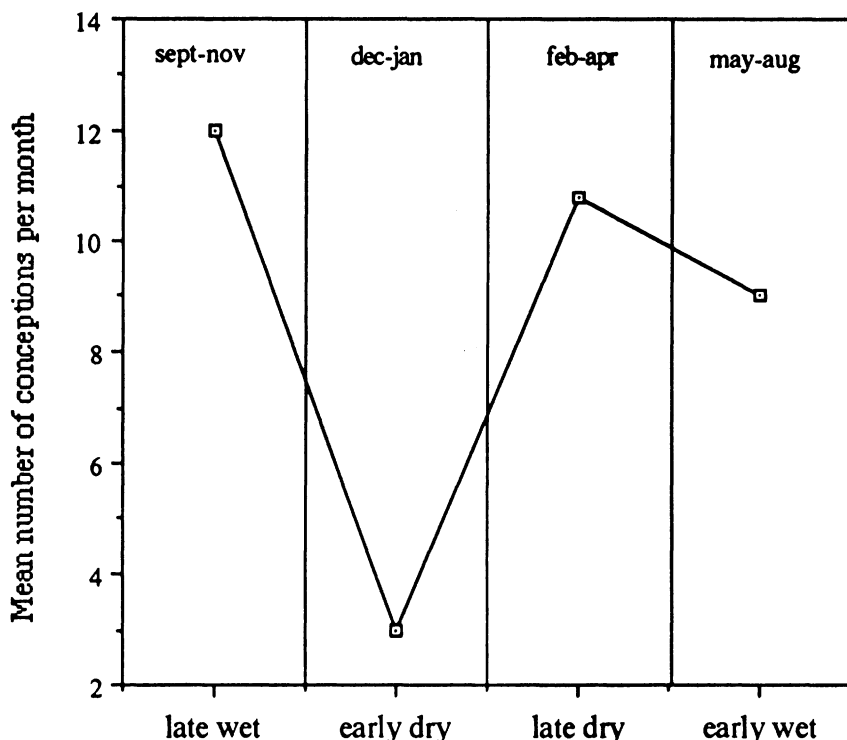
Figure 7. Mean Number of Pregnancies Reported by Hiwi Women per Month
and Grouped by Season

variable. We therefore decided to test for the effects of changes in *net* caloric intake by subtracting energy expenditure from energy intake.

Although work effort by women showed only small seasonal differences in absolute terms, the relative changes were enormous, with the high work season representing almost double the amount of work effort as the low work season. In order to calculate net caloric intake, we estimated women's energy output using the mean number of hours that women spent foraging in each season, the mean female body weight of women at risk of pregnancy, and the energy expenditure values reported in the literature for activities that are analogous to the foraging activities of Hiwi females.[8] Net energy intake by reproductive-age women was then defined as mean daily caloric intake minus mean daily caloric expenditure. Change in net energy intake was simply the measure of the difference between the net energy intake in one season and the net energy intake of the previous season. It should be noted that this procedure simply combines two of the variables from the first set of regressions (caloric intake and hours worked per day) into a single independent variable.

The analyses show that among women at risk of pregnancy (nursing and nonnursing women), the difference in net caloric intake between a season and

the previous season is a strong predictor of seasonal fertility rates among the Hiwi (Figure 8; F-test = 498.929, r^2 = .996, p = .002). Because we only have four data points (corresponding to the four seasons), because the measurements of all variables are quite crude, and because there is no reason to expect a linear relationship between the two variables tested, the strength of the correlation should be interpreted with caution. Nevertheless, the results are striking enough to encourage further investigation into the association between net caloric intake and fertility among women in natural fertility populations (see Bentley 1985). Interestingly, our results are consistent with research findings showing that in a sample of Western women, a *change* in nutritional status is a more important determinant of female fecundability than is nutritional status per se (Pirke, Broocks, and Tuschl 1988). It is important to note, however, that this test is designed to examine the determinants of seasonal variation in fertility, which may not be the same factors primarily responsible for fertility differences between individual women or between populations of women.
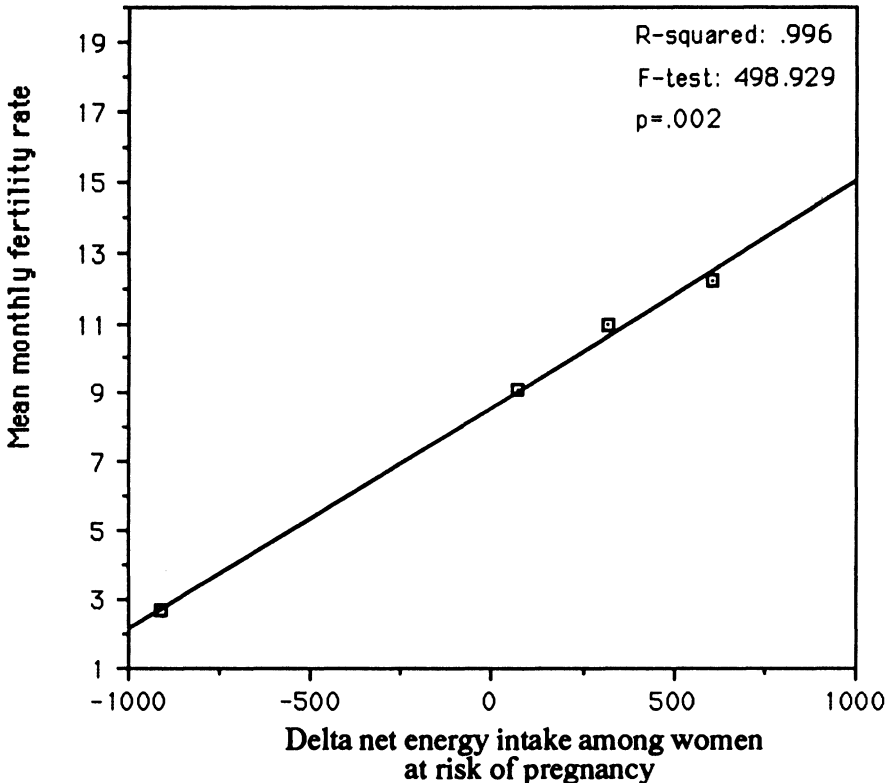

Figure 8. Relationship between Seasonal Changes in Net Energy Intake and Mean Monthly Fertility Rate among Hiwi Women at Risk of Pregnancy

DISCUSSION

Seasonal fluctuations in food consumption and in the sexual division of labor among the Hiwi took place within a hunting and gathering context during our sample period; the diet at their permanent central-place settlement was derived almost exclusively from wild foods. Preliminary analyses suggest that bush camps were characterized by an even greater dependence on foraged wild resources. We previously arrived at the same conclusion based on a smaller sample of two months of observations (see Hurtado and Hill 1987) and are now confident that until recently the Hiwi have been dependent on hunting and gathering for much of their subsistence.

Substantial amounts of meat from various sources were consumed at the Hiwi settlement throughout the year. Wild plant foods, in contrast, were sometimes scarce. The Hiwi may have been particularly carbohydrate stressed during certain months of the dry season when no vegetable foods are available or easily exploited. Over a year's time span, then, animal flesh appears to have been the "reliable" food, while vegetable foods were the more "variable" staple. This finding runs contrary to the commonly accepted generalization that the main, and more dependable, food staple among low-latitude hunter-gatherers is wild plants (Lee 1968; Eaton, Shostak, and Konner 1988:32).

One earlier study on the Hiwi allows us to compare our observations with those made during a different set of years. Arcand (1976) has published two weeks of quantitative data on the diet of a nomadic band of Colombian Hiwi that he observed in the late 1960s. His tables show that in February (late dry season), the Hiwi consumed a mean of 539 grams of meat, 357 grams of vegetables (roots), and 0 grams of fruits per person per day. Our February observations show a mean daily per capita consumption of about 900 grams of meat, 110 grams of roots, and 225 grams of fruits. In August, Arcand's observations show a mean daily per capita consumption of 521 grams of meat, 0 grams of roots, and 400 grams of fruits. Our July sample (we have no August data) shows a mean daily per capita consumption of about 850 grams of meat, 10 grams of roots, and 280 grams of fruits. Thus, the total amount of vegetables in both samples is about the same, but the component species differ. Meat consumption was consistently higher during our period of observation, but the major wild game species (capybara and fish) appear to be the same in both studies.[9] These two studies done fifteen years apart and on groups who live over 200 kilometers distant from each other do not allow us to conclude that year-to-year variation (or regional variation) is unimportant; however, they both conform to the patterns we document here.

SEX DIFFERENCES IN FOOD CHOICE

Both food availability and the foraging choices that the sexes make across seasons are important contributing factors to fluctuations in food consumption in the Hiwi diet. This is particularly interesting since differences in which

resources each sex chooses to exploit during the year result in variation in the character of the sexual division of labor. An increase in time spent gathering plant foods by men during the mango/chiga season and by women during the root season defines the sexual division of labor for each season and results in a more "balanced" diet during the wet season and possibly a more plentiful diet during the late wet season. The increased presence of carbohydrate in the diet at these times may be due to an increase in the caloric return rates associated with plant food gathering relative to overall foraging returns (Hawkes, Hill, and O'Connell 1982; Hill 1988), but the decision concerning which sex exploits plant resources seems less straightforward. Specifically, two main questions arise: (1) Why don't women hunt? and (2) Why do men, and not women, collect most of the mangos, and why don't men collect any other plant resources in significant amounts?

As is the case with many other groups of hunter-gatherers, the Hiwi data raise the important question of why women don't hunt as much as men (Hurtado 1985; Hurtado et al. 1985). This issue becomes clear when the caloric return rates from hunting and gathering are compared. In our sample, men obtained a mean of 2,593 calories/hour of hunting out of camp (search plus pursuit time). Hiwi women's food collecting across all seasons produced a mean of only 848 calories/hour of gathering away from camp. Preliminary data also suggest that processing time is much greater per calorie of vegetable food acquired than it is for game resources. Thus, the differential in hourly rates of edible food production from hunting and from gathering is even greater than the above measurements imply. If people wish to acquire as much food energy for their effort as they can, Hiwi women should hunt. In addition, meat has a higher content of proteins and lipids, both of which seem to be desirable (Hill 1988).

In other publications we have argued that the fitness costs to children and mothers associated with hunting and fishing may be an important determinant of female subsistence strategies. Specifically, we hypothesize that by hunting, women would drastically increase offspring mortality and decrease their own fertility. Since informants suggest that Hiwi mothers want as many children as possible, and want them to survive, they may not be willing to hunt if the increased food thereby obtained does not offset their losses in fertility and child survivorship. The decision not to hunt may therefore be adaptive in a strict biological sense if it results in more surviving offspring than could be produced by participation in hunting. Further refinements of this hypothesis are discussed in greater detail elsewhere (Hurtado 1985; Hurtado et al. 1985; Hurtado and Hill 1990).

The reasons why Hiwi men generally avoid plant gathering but do collect mangos when they are available may provide important insights into the sexual division of labor. From a simple energy maximizing viewpoint, the behavior of Hiwi men seems puzzling. During the early wet season, men acquired a mean of 2,919 calories per hour spent hunting. Although some mangos were encountered and collected while hunting, the vast majority were collected on special purpose trips for which the stated goal was to collect mangos, and no

other foraging took place. On mango-collecting expeditions, men acquired a mean of only 1,007 calories per hour, including travel time to and from the mango groves. Why should a man sacrifice almost 2,000 calories per hour to collect mangos rather than hunt?

One possible answer to the above question is that Hiwi men strongly desire some carbohydrate in their diet and are willing to sacrifice higher amounts of meat in order to obtain it. In a previous publication (Hill 1988), we have discussed the reverse case in which Hiwi men were observed to sacrifice higher amounts of food energy in the form of carbohydrates (roots) in order to acquire meat. Given that informants often stated the desire to complement the major macronutrients of their diet (carbohydrates, lipids, proteins) with those that were missing, and that observations suggest they often sacrificed higher caloric amounts of one macronutrient for lower amounts of another, we have begun to modify some simple maximization models to incorporate macro-nutrient complementarity (Hill 1988; Kaplan and Hill 1990).

If the desire for carbohydrate in the diet is a major factor in Hiwi men's foraging decisions, we must explain why the women do not collect more man-gos. Our current hypothesis concerning this issue is based on our impression that mangos have a unique pattern of spatial distribution, and this spatial dis-tribution has important implications for the costs of foraging to Hiwi women. Mangos are an attractive resource, but one that is potentially dangerous for women unaccompanied by men to collect. Mangos appear to be distributed in large groves, or patches, which may contain several million easily acquired calories in an area of about 5,000 m². Because of their size, caloric density, and ease of exploitation, these patches may be much more attractive than any other food patches in the Hiwi area, a situation which probably explains why local criollo populations exploit the mango groves but do not "forage" for many of the area's other resources. While following men collecting mangos, we encountered enemy Hiwi bands and Venezuelan criollos several times. Both groups are known to sexually harass unaccompanied Hiwi women, and both groups occasionally kill Hiwi foragers—men, women, or children. Thus women, who generally forage in small, single-sex groups, may avoid foraging for mangos unless their husbands or male kin accompany them.

Another cost to women associated with collecting mangos is the spatial distribution of this food resource. Animal behavior studies have demonstrated that foragers increase the size of the load they bring back to camp as the distance between the nest and the foraging site increases (Orians and Pearson 1979). In the Hiwi case, mango collecting may only be profitable for individuals who can bring very large loads to camp and whose effort is not greater than the benefits that can be accrued from carrying the nutritious package. For women, the costs of walking long distances with huge loads of mangos, in addition to their small children, may be sufficiently high to offset any nutritional gain made from gathering this fruit (see Blurton Jones and Sibly 1978:147). In contrast, Hiwi men may incur relatively low costs from collecting mangos since they are unencumbered by children and have larger body sizes. The advantages

of having men do most mango collecting should increase under conditions where plant foods are scarce close to camp and where the within-patch caloric return rates for gathering are extremely high.

The mango patches exploited by the Hiwi are very far from the main foraging camp; indeed, mangos are found much further away than any of the other plant foods that Hiwi women gather. Men exploit mango patches located 5, 6, 13, and 14 kilometers from the main camp. Two men in a canoe paddle at a rate of 4 kilometers per hour (upstream). We believe that women travel in canoes about half as fast, but this has not been measured. Allowing for an hour of collecting, round-trips take men from 3 to 9 hours to complete. We believe women would take roughly twice as long. Men also collect mangos from patches located across savannas that can only be reached by foot. Patches that we observed exploited were located 18 and 25 kilometers from the main camp. Men walk about 5 kilometers per hour in the savanna, and we believe that women walk at between 3 to 4 kilometers per hour. In many cases men left late in the evening to collect savanna mangos and returned the next morning (so as not to walk during the day). They generally carried back loads that weighed from 40 to 60 kilograms. Collecting mangos in savanna patches again takes only about an hour, and more eating takes place there than at riverine patches since savanna mangos cannot be transported in canoes. Thus, for men, collecting mangos in the savanna represents a minimum of from 7.6 to 11 hours of time away from camp. For women, this might mean 10 to 15 hours out of camp, and probably they could not carry such large loads over long distances without incurring high reproductive costs.

Additionally, the seasonal fertility data we have presented suggest that if women were to increase their annual work load by collecting mangos, they would probably experience decreased fertility. The effects of mango collecting on Hiwi men suggest that the increase in female work load could be considerable if women took over this gathering task. Men usually return from mango-collecting trips exhausted and soaked with sweat. In contrast to the mangos, the roots and fruits exploited by Hiwi women are almost always located within 2 kilometers of the main camp. Consequently, women can more easily find caretakers for infants and small children in the main camp until their return from gathering in the early afternoon (Hurtado and Hill 1990).

According to informants, Hiwi bands were more nomadic in precontact times than they are today. Under those conditions, men may have engaged in less fruit gathering than we observed because women were generally closer to collectible resources. Recently, as the Hiwi have become more sedentary, mangos appear to be the only available carbohydrate food in the late dry–early wet transition period of about two months. The maintenance of a permanent camp and the spatial distribution of mangos, along with a desire to obtain some carbohydrate in the diet, seemingly have led to Hiwi men collecting plant foods almost exclusively in the mango season. A complete test of our current working hypotheses will require considerable additional data collection.

In summary, it is possible that the *spatial distribution of wild plant foods with respect to camp sites* (or sites of food consumption) among hunter-gatherers may influence the timing of collection and the extent to which men gather those wild plant foods that women foragers generally collect. We have suggested that as the distance between the foraging site and camp increases, men may be more willing to do the gathering. This may be due to a combination of two factors. First, women may be more likely to be harassed and sexually abused by men from other groups when they visit mango patches at considerable distances from the main camp. Second, because the size of the load to be brought back to camp is expected to increase as the distance between food consumption and foraging sites increases, female work loads may also increase substantially. Thus women may ignore plant foods far from camp due to important energetic and reproductive costs. On the other hand, men, who are unencumbered by children, may choose to pursue, rather than ignore, scarce carbohydrate resources that are located far from main camps. This may be due to strong male preferences for balanced diets during seasons when women ignore gathering opportunities.

TIME ALLOCATION TO FORAGING: WHY WORK SO LITTLE?

The Hiwi spend few hours per day foraging in order to acquire food energy: men and women work less than three hours per day on average. Perhaps such a small subsistence effort would be expected if the Hiwi population were well nourished and more food would not be useful, but available data suggest that this is not the case. First, Hiwi of all age and sex classes constantly complain of hunger. The word for hunger, *jainpa*, was one of the first Hiwi expressions we learned, and it is a commonly heard expression in all Hiwi camps we have visited. The per capita consumption we measured is one of the lowest ever reported in careful quantitative studies of forager diets, and the consumption per kilogram of body weight is also very low (see Hurtado and Hill 1987). By comparison to the well-fed Ache that we have also studied (Hill et al. 1984), the Hiwi are shorter, thinner, and more lethargic and appear less healthy. The Hiwi also show significant seasonal fluctuations in body weights, are quite anemic, and suffer from substantial levels of parasitic infection, primarily by hookworms (Hurtado, Hurtado, and Hill 1989).

More important than all these health indicators, however, is the fact that there is good reason to believe that more food would increase survivorship among Hiwi children. Only 50 percent of all Hiwi children ever born survive to the age of fifteen years (Hurtado and Hill 1987). Most children die from diseases which are less likely to be lethal in well-nourished individuals (cf. Mata 1978). Numerous studies of subsistence-level populations around the world indicate that populations eating only as much, or even more, than the Hiwi are characterized by disease and mortality rates that may be directly affected by increased nutritional intake (Behm 1983; Chen 1983). Additionally, increased

food intake would probably raise Hiwi female fertility rates since we discovered that change in food intake was an important factor correlating with seasonal changes in Hiwi female fertility. We also found that among Ache foragers, higher female body weight correlates positively with female fertility rates (Hill and Kaplan 1987).

From a strictly biological point of view, how much food is enough for a human population depends on whether more food can either (1) increase survivorship rates, or (2) increase fertility rates. In the Hiwi case, as for most other foragers, we believe that more food would increase both parameters. Since Hiwi informants voice a desire for higher survivorship of children and higher fertility and since natural selection will always favor the desire to increase these two parameters, we conclude that the Hiwi are probably not getting the amount of food they would prefer. This point has been made several times in other discussions about time allocation to subsistence effort (e.g., Hawkes et al. 1985; Hill 1983; Hurtado 1985).

If more food would be desirable to the Hiwi and would have positive biological consequences, why don't men and women simply forage more? It is puzzling, for example, that Hiwi men do not spend more time hunting per day in spite of high hourly return rates throughout the year (2,593 calories/hour). Similarly, in the late wet season, the hourly return rate from women's digging of roots is also high (1,127 calories/hour), yet women spend a mean of fewer than three hours foraging per day.

We believe that the most likely explanation for this low work effort is that increased time spent foraging may be accompanied by costs to the individual doing the work that more than offset the benefits he/she might derive from increased food production. In the Hiwi case, seasonal fluctuations in body weights among all adults and cyclical variability in female fertility provide some appreciation of the costs of subsistence effort. Both men and women lose weight during the periods of the year when they increase work effort (the late wet season for women and the late dry season for men), and women and men attain their highest weights during the seasons of the year when they do the least amount of work (the early and late wet seasons). These patterns are observed despite the fact that foraging return rates in calories per hour (2,593 among Hiwi men and 848 among Hiwi women) are higher than energy expenditure rates (about 480 calories per hour maximum) throughout the year and that the increases and decreases in foraging effort across seasons are small (0.2–1.9 hours/day).

Low female reproductive rates also appear to be an important health consequence of increased time spent foraging by Hiwi women. Relatively high levels of female work during the late wet and early dry seasons, in combination with a subsequent decrease in caloric consumption during the early dry season, coincide with a sharp decline in fertility in the early dry season. A decrease in net energy intake appears to be the most important predictor of fertility differentials across seasons.

These analyses suggest that if the Hiwi were to greatly increase time spent

foraging over current levels, both men and women would suffer even greater nutritional and reproductive losses than those they currently experience. It is possible that women would suffer even greater levels of infertility (see Hurtado and Hill 1987), and men would be skinnier and less robust. Thus Hiwi individuals may be avoiding these important nutritional and reproductive costs by limiting foraging effort to less than four hours per day.

We are still left with the question of why *slight absolute increases* in the time the Hiwi spend foraging during some seasons of the year lead to negative health outcomes in the short run. Two ecological factors might be responsible for this pattern. The entire Hiwi population experiences high levels of hookworm infection (Hurtado, Hurtado, and Hill 1989). The blood loss associated with this type of parasitic infection (Warren 1981; Bloch 1986) is in turn partially responsible for high levels of iron deficiency anemia among the Hiwi (Hurtado, Hurtado, and Hill 1989). Anemia negatively affects exercise performance and work output (Basta et al. 1979). In addition, it is not clear to what extent heat stress exacerbates the negative effects of parasitic infection on stamina (Newman 1975; Calloway 1982b). Hiwi informants often complain about the heat and attribute headaches and overall physical discomfort to sun exposure. Consequently, it is not surprising that most Hiwi prefer to forage very early in the morning or late in the day and that the most important in-camp activities in the middle of the day are resting and sleeping in hammocks (unpublished data). Thus, we tentatively propose that the combined effects of heat stress and parasite load on health are important costs to Hiwi individuals when they forage and that these costs more than offset the benefits they might derive from increased food production. We suspect that among the Hiwi, these factors increase the costs of foraging relative to those incurred by members of other hunting and gathering groups such as the forest-dwelling Ache. The Ache are extremely energetic, regardless of time of day. Substantial forest cover and lower temperatures may be partially responsible for these high activity levels compared to Hiwi foragers.

In summary, even though the Hiwi "enjoy" a leisurely fifteen-hour week, their nutritional and reproductive viability may be quite vulnerable to slight changes in foraging effort due to disease, ecology, and heat stress. Findings about the relationship between foraging effort and female fertility suggest that in their savanna environment, there is only a small window of time during which Hiwi women and men can acquire food without negatively affecting their reproductive viability and/or health status. Women may limit their work effort primarily to maintain desirable fertility levels, and men may limit their work effort so as not to reach undesirably low body weights.

CONCLUSIONS

Analyses show that there is considerable seasonal variation in the diet, work effort, nutritional status, female fertility, and sexual division of labor among Hiwi central-place foragers of the Venezuelan savanna. Seasonal variability

along various parameters has helped us examine the relationships among fluc-
tuations in ecological conditions, adult health status, and the character of the
sexual division of labor in this group of hunter-gatherers.

In spite of a long history of extensive contact with outsiders, hunting and
gathering were the primary means of subsistence among the Hiwi throughout
our sample period. Meat was the major food staple during most seasons and
the most constant source of food energy across seasons for Hiwi foragers.
The acquisition of plant foods, on the other hand, varied greatly across the
year, thereby creating seasonal peaks and troughs in food energy intake.

In a previous study, we found that among Ache foragers, meat also was a
more reliable food resource over a yearly cycle than were wild plant foods. If
in other foraging populations meat is the more constant food staple across
seasons as well, this evidence would have important implications for under-
standing the apparent pervasiveness of male food provisioning in humans. If
most local ecologies tend to experience plant food shortages more often than
game scarcity, then fitness incentives for males to acquire food for their mates
and putative offspring, who might experience high mortality without such as-
sistance, may be pervasive. Even periods of vegetable scarcity as short as a
few weeks per year might provide strong selective pressures for male food
provisioning if females do not hunt.

Seasonal fluctuations in the Hiwi diet reflect variability in the sexual division
of labor across the year. Both men and women contributed to the balanced
diet of the wet season months: females dug roots and gathered some fruit,
while males engaged in both hunting and gathering fruits. During the dry
months, however, men were the primary food providers, and meat was the
main food staple. Because women's food contribution was only equivalent to
that of men during the season when roots were taken in very large quantities,
during three seasons of the year Hiwi females were dependent on their hus-
bands and male kin for their children's and their own food energy consumption.
Interestingly, during one season of the year, women depended on men not
only for meat but also for plant foods. We suggest that among the Hiwi foragers,
the spatial distribution of wild plant foods with respect to camp sites and
macronutrient complementarity influence the timing of collection and the extent
to which men gather the wild plant foods that women generally acquire.

Data on Ache, Duda (Draper 1984), and Agta (Goodman et al. 1985) hunter-
gatherers over the seasonal round also show that women depend on men for
most of their food consumption throughout the year (Hurtado et al. 1985).[10]
Again, comparative data are too scant to assess the generality of these trends.
However, if future data indicate that female foragers generally tend to be more
economically dependent on men than not, then we need to ask what social
mechanisms might have led to this "universal" outcome and what aspects of
food acquisition away from camp may be important deterrents to women's
increased work output under (possibly) numerous conditions.

One important deterrent among Hiwi women appears to be impaired fertility.

In the population sampled, Hiwi female fertility was sensitive to changes in net energy balance. A drastic *relative* (not absolute) increase in work output between two seasons affected temporal fluctuations in net energy intake, and these fluctuations were highly correlated with seasonal variation in female fertility. The finding that a slight increase in female work effort can negatively affect female fertility suggests that if Hiwi women were to become much less economically dependent upon their husbands for their daily sustenance, their reproductive rates would probably decline below present levels.

Finally, we were faced with the issue of why both men and women in Hiwi society allocate relatively little time to foraging when data on hunting and gathering efficiency, as well as data on Ache foragers, suggest that individuals could be nutritionally much better-off if they increased work output. Seasonal weight loss patterns among the Hiwi may shed some light on this question: slight increases in men's and women's foraging efforts were associated with significant weight losses in the population sampled. We suggest that chronic parasitic infections and heat stress might be partially accountable for this pattern. These conditions may work synergistically so that slight changes in work output can very quickly have negative biological consequences such as weight loss. Parasites and heat stress among the Hiwi possibly increase the costs associated with their foraging relative to groups of hunter-gatherers who live in areas with forest cover and lower temperatures (e.g., the Ache of eastern Paraguay). If this inference is correct, then differences in disease vectors and climate may partially help explain why the Hiwi are less active than hunter-gatherers who live in forests.

In conclusion, this study of seasonal variation deals with various aspects of the sexual division of labor in one group of savanna hunter-gatherers of the New World. It is hoped that the quantitative descriptions as well as the hypotheses presented will motivate future research on the ecological determinants of sex differences in subsistence strategies.

NOTES

1. We would like to thank Raymond Hames for very useful comments on several versions of this manuscript. We are also very grateful to the Hiwi for their friendship, patience, and cooperation and to the Hurtado family for their generous logistical support. The research was funded by grants from the National Science Foundation and the L.S.B. Leakey Foundation.

2. The term "sexual division of labor" is not used to imply that a joint or common economic or reproductive goal exists for the two sexes. It is simply used to describe sex differences in time spent foraging, in the quantity and types of food that are acquired, and in food sharing between the sexes.

3. "Hiwi" is the English spelling of *Jigui*, the spelling that is used in Guajiboan practical orthography. Because earlier authors have used the English spelling, we retain it here.

4. In order to protect the study population, this and all subsequent locational references have been fictionalized. Band names are also fictional in order to protect study subjects.

5. Arcand states this emphatically in the film *Last of the Cuiva*, part of the Disappearing World Series produced by Granada Film Productions, London, England.

6. We have chosen children 3.5 years old because by this age they are totally dependent on solid foods. Ideally, we should present consumption rates that control for the age structure of our population and should incorporate in our analyses the lower caloric consumption of young children and the decreased caloric consumption of old individuals, as well as the high consumption rates of adolescents. However, this would require scaling food consumption to an almost daily fluctuation in the age structure of the population. This level of precision is probably unwarranted for the gross-level patterns we are attempting to characterize (see also Hill et al. 1984; Hurtado and Hill 1987).

7. Details of this resource are purposely left ambiguous because of its sensitive nature. More information may be obtained by writing to the authors.

8. For the calculations of net caloric intake among Hiwi women, we assumed an energy expenditure level of 5 cals/kg/hr for time spent in fruit collecting and 7.4 cals/kg/hr for time spent in root acquisition (analogous activities in Hill et al. 1984, Table 5, are "collecting" and "chopping tree" used in the analyses of Ache women's energy expenditure). We multiplied these numbers by the mean number of hours that women at risk of pregnancy (mainly nursing and nonnursing women) spent foraging for either roots or fruits in each season of the year. These products were then multiplied by the mean number of kilograms that women at risk of pregnancy weighed in each season. The resulting number represents a rough approximation of the relative differences in energy expenditure among women at risk of pregnancy in each season of the year. In order to arrive at an estimate of net energy intake, this estimate of energetic expenditure was then subtracted from the mean daily per capita consumption for each season as reported in Table 5.

9. Thirty percent of the total kilograms of meat acquired by the Hiwi we observed comes from feral cattle, which were apparently absent in Arcand's sample. This absence appears to account for the differences in meat consumption between the two studies.

10. !Kung (Lee 1979) and Gwi San (Tanaka 1980) foragers show the opposite pattern, with women acquiring more than 50 percent of the total calories. However, both data sets only represent the one month of the year when mongongo nuts are the major food staple.

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