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Comparative Aspects of Diet in Amazonian Forest-Dwellers

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Comparative aspects of diet in Amazonian forest-dwellers

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SUMMARY

Recent research shows that lowland forests of the Amazon Basin differ in numerous ways including features of climate and soils, faunal composition and forest structure, composition and phenology. Such differences strongly suggest that single-factor models used to explain features of human ecology in Amazonia may be too limited. A comparative study of the dietary ecology of four forest-living indigenous groups in Brazil (Arara, Parakana, Arawete, Mayoruna) revealed a number of differences. Primary crops, as well as animal types most utilized as prey, were found to differ markedly between groups. Although some differences can be accounted for by general environmental factors, no compelling single environmental factor can explain why any one group could not behave dietarily in ways more similar to another. Many of these intergroup dietary differences appear to represent a type of cultural character displacement that aids in distinguishing the members of one group from another. As all human groups, through the medium of culture, are actual or potential occupants of the same dietary niche, each group may distance itself from potential dietary rivals through cultural conventions. This behaviour may be justified, as the lack of overlap between forest-living groups in combination with generally intense intergroup hostility suggests that the biomass and distribution patterns of critical dietary resources in this environment may set limits to viable population size for particular areas.

1. INTRODUCTION

Single factor hypotheses related to diet have been invoked to explain numerous aspects of human ecology in tropical forests of the Amazon Basin, including population and settlement size, patterns of residence and nomadic and semi-nomadic behaviours (Meggers 1954, 1971; Carneiro 1960; Gross 1975). Limited dietary resources have been suggested to influence behavioural traits such as aggression, warfare and infanticide (Harris 1974; Chagnon & Hames 1979; Werner 1983). It has been hypothesized that tropical rain-forest environments are so nutrient-poor that human populations could not survive in them without access to crop foods (Headland 1987; Bailey *et al.* 1989). Tropical forest dwellers are often denigrated by terms such as 'marginal' peoples or 'refugees', the implication being that no one would choose to live in such an environment if other alternatives were possible (Lathrap 1968). All of this creates a largely negative and greatly oversimplified picture of tropical-forest peoples and their environment.

One common problem with these explanations has been the fact that most have been advanced without detailed knowledge of the potential of local dietary resources or actual food habits of the associated indigenous inhabitants (Hames & Vickers 1983). Often present-day environmental or dietary conditions are ascribed to the past without good historical or archaeological evidence. I suggest that all of the single-factor dietary models used to explain features of human ecology in forests of the Amazon Basin may have been pre-destined to failure by their attempts to provide a single generic explanation for what is, in effect, a vast and complex mosaic of different dietary possibilities calling for a variety of different solutions by human foragers (Dwyer 1986). These differences include: (i) wide regional and seasonal variation in rainfall patterns and hours of solar insolation; (ii) a range of soil conditions as diverse as in temperate zones (Sanchez & Buol 1977); (iii) a number of forest types with structure, composition and phenological production patterns which vary within, as well as between, geographical regions (Balee 1989; Gentry 1990; Bodmer 1990); and (iv) variation in the composition, distribution patterns and biomass of the associated faunal communities (Janzen 1974; Bodmer 1990). Given all of these differences, it seems logical to assume that the human inhabitants of such forests might face a wide range of different possibilities with respect to dietary potential.

2. THE MONKEY MODEL

My interest in the dietary ecology of neotropical forest dwellers was stimulated by earlier work on the diets of non-human primates in this same environment (Milton 1981, 1987). In the neotropics, non-human primates are confined to the forest canopy where the

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largest biomass of digestible plant matter occurs. By specializing on different subsets of the available plant resources, generally supplemented by second trophic level foods, a large number of primate species are able to coexist sympatrically (Hershkovitz 1977; Terborgh 1983).

In non-human primates, strong intraspecific aggression between groups is the norm; as members of the same species, they occupy the same dietary niche, and intense dietary competition is expected to prevail. In contrast, interspecific aggression between sympatric groups of non-human primates is relatively rare because each monkey species has its own dietary niche.

In contrast to non-human primates, humans live on the forest floor where the biomass of edible plant matter is generally low. Similar to conspecific monkey groups, human groups in the Amazon Basin show a strong tendency to repel or discourage other human groups from utilizing their supplying area; this antipathy generally holds whether non-residents speak the same or a different language than residents. In ecological terms, it would appear that the establishment of one human group in a given area has a decidedly negative effect on the probability of establishment of another human group within the same area. Given all of the disturbances to indigenous populations in the Amazon Basin since contact, this spacing pattern may now be less obvious than in the past. However, the large number of different language groups known to have occupied forests of the Amazon Basin pre-contact (Nimuendaju 1987), in combination with the present-day locales of remaining groups (Lizarralde 1991), strongly suggests that in the past (and, in many areas, even today) Amazonian lowland forests were well saturated with indigenous groups, each of which strived to maintain exclusive use of its particular supplying area (Roosevelt 1980; Balee 1984).

The spacing behaviour of humans in forests of the Amazon Basin thus suggests that some features of human ecology or behaviour in this environment prohibit or minimize the potential for overlap. By analogy with non-human primates, dietary factors would appear to be implicated. To understand better what such factors might be, I here examine the respective forest environments and diets of some forest-living groups.

3. STUDY GROUPS

These forest-based groups have lived for many successive generations within the vast expanses of upland terra firme forest and should not be confused with other indigenous inhabitants of the Amazon Basin, such as riparian fisher–gardeners (e.g. the Tukanoans) or savannah–transition woodland peoples (e.g. the Kayapo). The inhabitants of these environments differ from one another in a large number of traits, including physical traits (Milton 1983), and typically reside in quite different ecological zones.

Although they were forest-dwellers, all the groups I worked with not only hunted and gathered but also practised slash-and-burn horticulture and are best regarded as hunter–gatherer–horticulturalists (HGH). Forest-based peoples should not be viewed as ahistorical, static isolates (see, for example, Schire 1984; Vansina 1990). Rather, all such groups have obviously been affected over centuries by contact both with other, generally hostile, indigenous groups and by outside influences, including trade goods, new cultivars and new diseases (Posey 1987; de Castro & de Andrada 1988; Roosevelt 1989). None the less, it is still possible to find little-acculturated groups who are long-term inhabitants of forests of the Amazon Basin, who still hunt almost exclusively with their traditional weapons, and whose food (possibly excluding salt) is still obtained through their own efforts and interactions with their forest environment. The four groups discussed in this paper conform to this description.

Three of the four study groups – the Arara, Parakana and Arawete – live in central Pará state, Brazil (figure 1). What is known of their history suggests considerable transitional movement throughout this region, such that in the past, one group may actually have lived in, or very near, an area now occupied by another. Actual hostilities are known to have taken place between at least two and possibly all three of these groups, in one case (between the Arawete and Parakana) as recently as 1983 (Arnaud 1983; de Castro 1988; de Castro & de Andrada 1988). The fourth group, the Mayoruna, lives to the west of the other three in the state of Amazonas (figure 1).

The Arara are Carib speakers presently settled north of the Iriri River (figure 1). They have lived in Pará for centuries, presumably having migrated south from the Brazil–Guiana region where a number of Carib-speaking groups still occur (de Castro & de Andrada 1988). Once estimated to consist of more than 300 individuals, the total group today consists of around 90 people. My work was done in Curambe, a small village on the Iriri River inhabited by 20 Arara, ten of whom were adults. During my study, the residents of this village were moved by the Indian Bureau (FUNAI) to a new site called Ikopty, closer to the junction of the Iriri and Xingu Rivers and the larger Arara village of Laranjal.

The Parakana, a group of approximately 350 individuals, live in three villages in the region between the Tocantins and Xingu Rivers. They speak a language of the Tupi–Guarani linguistic family. The village I worked with was located approximately 30 km east of the Xingu River on a small tributary called Bom Jardim (figure 1). This village is unusual in that until two years before my study its inhabitants had lived for 20 or more years as nomadic hunter–gatherers in the forest in an effort to escape attacks from hostile Gê-speakers and outsiders. In 1983, after being contacted by the Indian Bureau, 105 Parakana agreed to settle in the Bom Jardim area, and in 1984 they were joined by another 31 nomadic Parakana (Magalhães 1988).

The Arawete speak a language of the Tupi–Guarani linguistic family. This group used to live further east in the vicinity of the Bacaja River (de Castro 1988). Hostile attacks by the Xicrin–Kayapo apparently forced them to migrate west, displacing the Assurini in

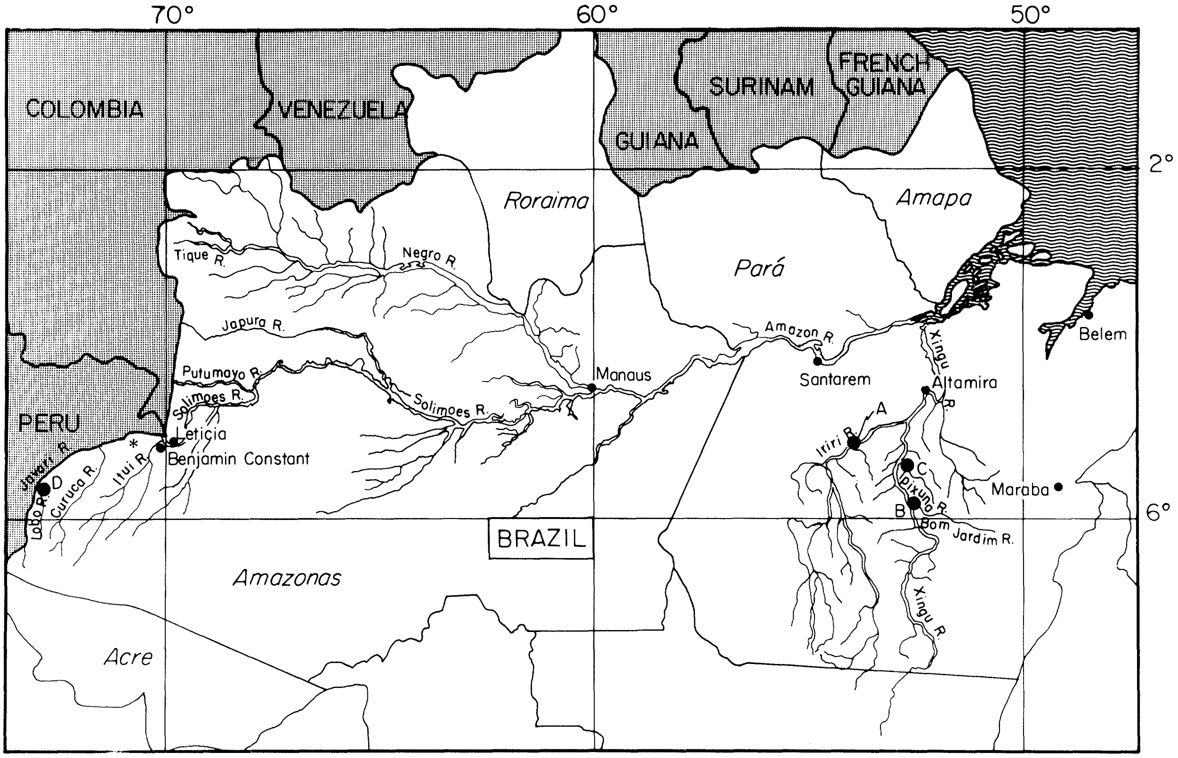

Figure 1. Study locales: A, Arara; B, Parakana; C, Arawete; D, Mayoruna. Note: * indicates tree-collection site for the Mayoruna area.

the process. Currently the entire group consists of some 110 individuals in a single village on the Ipixuna River, a small tributary east of the Xingu River (figure 1).

The Mayoruna, Panoan speakers, live east and west of the Javari River in Peru and Brazil. This group is noted for its extremely aggressive behaviour; its raids on settlers and river boats, and abduction of women, made the Javari River region unsafe for outsiders until the 1970s. The Mayoruna group I studied consisted of 117 individuals living in the state of Amazonas on the Lobo River, a small tributary of the Javari River (figure 1).

4. RESEARCH PROTOCOLS

(*a*) *General*

Three groups were visited on two occasions to compile data at different points in an annual cycle. Time constraints permitted only one visit to the Arawete. At each locale I collected environmental data, including daily rainfall and temperature range, soil samples, floral samples and phenological information. Data compiled on group members included height, mass and dental information. Activity budgets for adult men and women were recorded. Game and plant foods seen entering each village (or selected households) were identified and weighed. Fields were measured, crop types recorded and harvest mass obtained. Space constraints prohibit detailed discussion of all sampling protocols. Information on specific protocols relevant to data presented in this paper is given below.

(*b*) *Environmental factors*

Local climatic features were monitored by a maximum–minimum thermometer and standard rain gauge read at the same time each day. Mean annual rainfall and hours of solar insolation (see figure 2) for the two main study areas (central Pará and western Amazonas) were obtained from SUDAM, a Brazilian environmental agency. Soil collected at each site included samples from: (i) freshly burned fields; (ii) fields under cultivation for around 2 years; (iii) forested areas adjacent to fields; and (iv) undisturbed forest areas. Soil samples were analysed for several standard features by Agro Services International, Orange City, Florida. Forest composition was sampled by 0.25 or 0.5 ha† sample plots laid out in undisturbed terra firme forest in each study site. Within each plot, all trees greater than 10 cm d-b-h were measured and tagged. For three sites (Arara, Parakana and Mayoruna), professional tree collectors obtained botanical specimens from sample plots; most specimens were later identified to genus and species.

(*c*) *Diet*

As the collection of dietary data was a central focus of my study, I brought in my own food supplies so that local inhabitants would not have to secure food for me nor hide food for fear I would eat it. In each village I recorded the identity of all foods I saw and weighed all plant foods and game to which I could obtain access. I particularly tried to determine which crops and prey items were most frequently utilized in the daily diet.

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† 1 ha = 10^4 m^2.

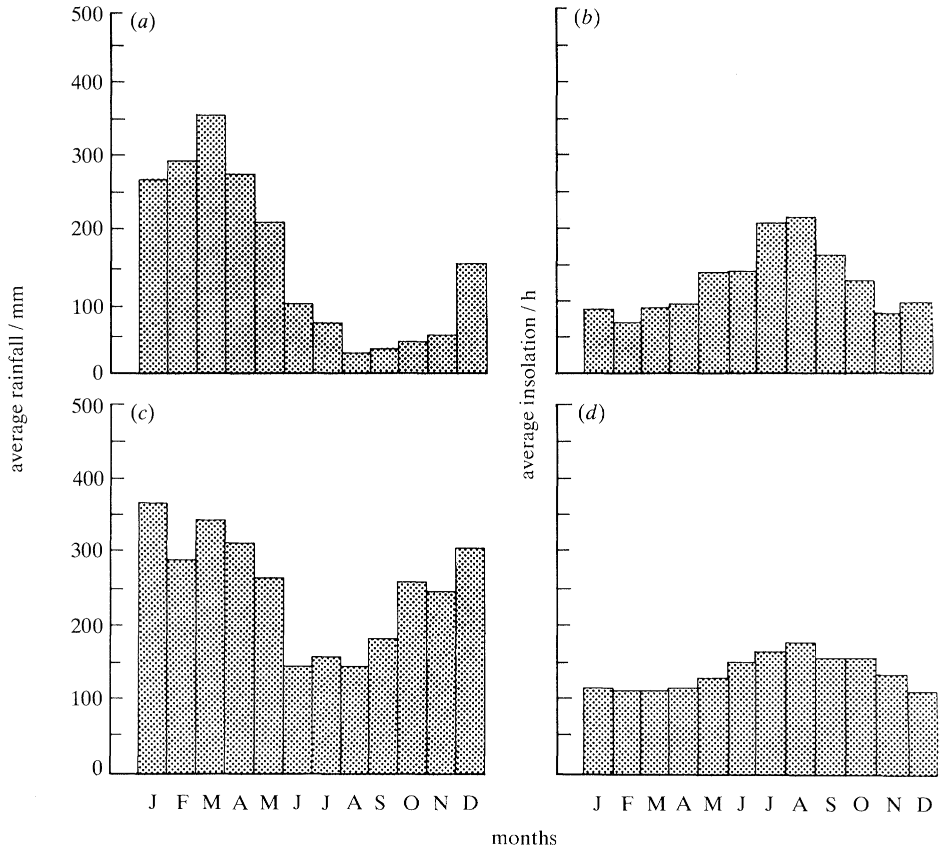

Figure 2. Averages over 20 years for monthly rainfall and solar insolation patterns for the two main study areas, central Pará state and western Amazonas state, Brazil. A and B: central Pará, station-Marabá; lat: 05°21′S; long: 49°09′W; altitude 102 m. C and D: western Amazonas, station-Benjamin Constant; lat: 04°23′S; long: 70°02′W; altitude 80 m. Figures redrawn after those presented in Atlas Climatológico da Amazônia Brasiliera, Ministerio do Interior, SUDAM/PHCA, Belém, Pará, 1984.

These I termed primary dietary resources, subdivided into two classes, primary carbohydrates and primary prey, defined for purposes of this paper as follows.

The primary carbohydrate for each group was defined as the plant food estimated to provide the highest percentage of calories in the daily diet on an annual basis. Because my stay in each village was substantially shorter than an annual cycle (table 1), I made this decision based on data from examination of fields and observations of plant food consumption. Indigenous informants and Indian Bureau employees also supplied information on seasonal dietary habits.

Primary prey for each group were defined as the animal types most frequently eaten. To determine primary prey I examined hunt return data from each group visit, and sorted prey into specific categories. I then totalled the number of prey items seen for that visit and calculated each prey category as a percentage of the total. Though the mass of many prey items was recorded, as well as the number of hunters and hours per hunt, discussion of these data is beyond the scope of this paper.

4. RESULTS

(*a*) *Variation in environmental factors*

Monthly data on rainfall and solar insolation patterns presented in figure 2 confirm regional and seasonal differences in these parameters for the two main study regions. Similar differences were noted for my on-site rainfall data. No general statements can be made with respect to soil analyses other than to note confirmation of the well appreciated fact that clearing and burning forest cover greatly enriches soil fertility for periods lasting longer than two years. These results were consistent regardless of locale. However, in the total data set, some in-site differences in soil parameters were as profound as between-site differences. Space does not permit discussion of these often complex results, which are presented in a separate publication (K. Milton, in preparation). Information on forest composition is presented in table 1. At the family level, forest composition did not differ notably between sites; there were, however, striking local differences in the number of genera and species per family, as well as the number of stems. For example, forest plots of the Mayoruna contained no arborescent palms; in contrast, palms were one of the best represented families in forest plots of the Arara and Parakana in Pará (table 1).

(*b*) *Variations in primary carbohydrates*

Important crops of the Arara included sweet potatoes (*Ipomoea batatas*), bitter manioc (*Manihot esculenta* Crantz), corn (*Zea mays*) and bananas (*Musa*

Table 1. *Forest composition by site*

tribe	number of stems per ha ⩾ 10 cm dbh	number of families	families with greatest number of genera		families with greatest number of stems		percentage of total stems in Palmae
Arara	467 composite of data from four 0.25 ha plots from 3 areas 1–2 km apart	37	Leguminosae	23	Leguminosae	114	13.1 %
			Moraceae	10	Bursuraceae	99	
			Crysobalanaceae	9	Palmae	61	
			Annonaceae	8	Lecythidaceae	29	
			Bursuraceae	8	% of total = 64.9		
Parakana	397 composite of data from two 0.5 ha plots approximately 1 km apart	41	Leguminosae	26	Palmae	63	15.9 %
			Moraceae	13	Leguminosae	45	
			Lauraceae	7	Moraceae	39	
			Flacortiaceae	7	Bursuraceae	28	
			Bursuraceae	7	Rutaceae	22	
			Meliaceae	7	Meliaceae	21	
					% of total = 54.9		
Arawete	408 estimated from data on one 0.25 ha plot which contained 102 stems	n.d.	n.d.		Meliaceae	22[a]	3.9 %[b]
					Sterculiaceae	20[a]	
					% of total (102 stems) = 41.1		
Mayoruna	582 composite of data from two 0.5 ha plots approximately 1 km apart	42	Leguminosae	21	Lecythidaceae	74	0.0 %
			Crysobalanaceae	18	Crysobalanaceae	57	
			Sapotaceae	18	Myristicaceae	54	
			Myristicaceae	15	Leguminosae	49	
			Moraceae	11	Sapotaceae	41	
			Euphorbiaceae	11	Morasceae	39	
					Euphorbiaceae	38	
					% of total = 60.5		

[a] stems of these genera noted to be abundant in the one 0.25 ha plot surveyed.
[b] 3.9 % Palmae in 0.25 ha plot.

spp.). Corn was a highly seasonal resource, whereas sweet potatoes, manioc and bananas were more or less continuously available. The primary carbohydrate of the Arara was a fermented beverage known colloquially as 'pik-tu'. It can be manufactured from almost any crop, but the Arara preferred sweet potatoes, presumably because they can be converted into a beverage far more rapidly than manioc or corn, both of which require extensive and time-consuming preparation.

While living as nomads, the Parakana made a type of gruel or bread from mesocarps of the babaçu palm nut (*Orbignya* sp.) and infructescences of the 'banana brava' plant (*Phenakospermum guianensis*). My phenological data show that ripe babaçu nuts are available in the forests of Pará throughout the year; informants stated that banana brava also fruits throughout the year.

The primary crop of the Parakana is bitter manioc (*Manihot esculenta* Crantz). The Parakana at Bom Jardim had planted manioc and consumed it during my study. Manioc roots are soaked for approximately three days in the river and peeled. The soft, water-soaked roots are squeezed into balls by hand which are then dried on a rack over a fire. The resulting material is crumbled through a sieve and used to prepare manioc bread or, occasionally, farinha (manioc cereal). Manoic and babaçu products comprised almost the total carbohydrate substrate for the Bom Jardim Parakana during both visits.

The Arawete were the most unusual group in that their primary carbohydrate was corn (*Zea mays*), which was consumed year-round rather than seasonally. De Castro (1988) states that the Arawete are the only Tupi group that cultivates corn for year-round consumption; they are the only forest-based group I have ever observed which has this custom. Each year, they clear large areas (one hectare or more) to make new corn fields; these are not necessarily placed on flood plains but can be found well inland. Once mature, corn is tied with vines in palm frond bundles, stacked on logs, covered and left in the fields. Every few days, groups of men travel to the corn stack, collect baskets of corn, each averaging approximately 22 kg, and bring them back to the village. Corn is removed from the cob, roasted on a large griddle, pounded to a powder in a wooden mortar and stored in tightly woven baskets.

The Arawete eat powdered corn throughout the day. A type of gruel is commonly prepared from corn and probably fresh corn is eaten roasted. There is no important secondary food crop for the Arawete: corn is the dietary keystone in terms of caloric intake. Balée (1989) has estimated that 82 % of land under cultivation by the Arawete is devoted to corn, and this figure probably would be even higher if rice had not recently been introduced.

To quantify the importance of corn in the Arawete diet, I did some spot sampling of dietary items over a period of days, taking equal numbers of samples for each hour between 0800h and 1800h. Of 284 scans, corn powder accounted for 46 % and corn gruel 2 %.

Table 2. *Prey items recorded for each group (number and %[a] of total for that sample period)*

		tortoise		bird		fish[b]		monkey		peccary		agouti		paca		armadillo		tapir		deer[d]		larvae		other	
group		number	%	number	%	number	%	number	%	number	%	number	%	number	%	number	%	number	%	number	%	number	%	number	%
Arara	1985 (1)[c]	14	16	15	17	24	28	17	20	8	9	—	—	4	5	—	—	—	—	—	—	—	—	5	6
	1986 (2)	4	11	6	17	8	23	10	29	—	—	2	6	—	—	1	3	—	—	—	—	—	—	4	11
Parakana	1986 (3)	80	44	7	4	5	3	—	—	10	6	4	2	30	17	32	18	1	< 1	4	2	7	4	—	—
	1986 (4)	22	28	5	6	14	18	—	—	2	3	3	4	12	15	6	8	1	1	—	—	2	3	9	2
Arawete	1986 (5)	59	35	70	41	6	4	3	2	4	2	13	8	1	< 1	9	5	1	< 1	3	2	—	—	—	—
Mayoruna	1986 (6)	2	11	1	5	2	11	5	26	2	11	—	—	1	5	—	—	1	5	1	5	—	—	4	21
	1987 (7)	5	8	6	9	13	20	8	12	23	35	2	3	3	5	1	2	—	—	1	2	—	—	3	5

[a] All percentages rounded to the nearest whole number.

[b] Fish: each return with fish; 1 fish or many scored as 1; mass of fish returns generally were recorded.

[c] (1) 7 October–11 December; (2) 20 April–8 May; (3) 10 March–11 April; (4) 28 July–20 August; (5) 12 April–9 May; (6) 27 November–7 December; (7) 15 February–22 March.

[d] Generally killed for non-Indian consumption or believed to be a post-contact adaptation.

Rice (by chance being harvested) accounted for 27% of the scans. If my sample had not coincided with the rice harvest, I feel confident that corn products would have made up more than 75% of the total sample.

For each group, data were compiled on the size and condition of the residents' teeth. The Arawete had extremely poor teeth relative to other groups, who generally had excellent teeth. Individual Arawete as young as 19–24 years of age had molar teeth missing, as well as some premolars, and conditions only worsened with age. The poor condition of Arawete teeth may result from abrasive action of corn powder on dental enamel and the continuous decay of corn starch at the gum line.

The Arawete drank, and cooked corn only in fresh water from water holes which they dug in a clay-based substrate. They also ate clay from the bottom and sides of these water holes. Chemical attributes of this water may enhance nutrients found in corn, or aid in detoxification of adverse chemicals in the Arawete diet (see, for example, Johns 1990). A non-dietary possibility is that, by drinking only ground-filtered water, the Arawete may avoid water-transmitted parasites.

The Mayoruna generally place their large fields on hills rather than flat ground. They were the only group observed to weed fields. Their primary crop is sweet manioc (*Manihot esculenta* Crantz), which is boiled and eaten or processed into farinha. This farinha is yellow in colour, in contrast with the pale cream colour of farinha manufactured from bitter manioc. The second most important crop of the Mayoruna is bananas, particularly plantains. In summary, each group utilized a different primary crop (table 3).

(*c*) *Variation in primary prey*

Primary prey also showed wide variation between groups. The Arara consumed the widest range of prey species, including sting rays and electric fish; the intestinal tract of a wide variety of mammals was routinely consumed. Pinto (1989) reports that vultures, house rats and hawks are eaten by the Arara when other meat is not available. The single most important prey item of the Arara was monkeys, particularly capuchin monkeys (*Cebus apella*) (table 2). In samples, monkeys accounted for 20–29% of the total prey brought back to the village. This percentage is a minimum estimate as I was not able to quantify individually 38 kg of smoked game, largely monkeys, brought back to the village for a festival. The Arara maintain large numbers of monkeys in the village as pets, obtained when their mothers are killed for food. The study group also included a notable amount of fish in the diet (table 2). The dietary importance of fish appears to be recent, resulting from settlement of the Arara near the Iriri River by the Indian Bureau who also provided hooks and lines. At the larger Arara village, Laranjal, fishing is regarded as an activity of little value (Pinto 1989).

In striking contrast to the Arara, the Parakana are specialists on terrestrial game, particularly land tortoises, tapir and wild pigs, but also armadillo and paca (table 2). They hunt with dogs, which is effective for

Table 3. *Summary of dietary differences*

group	primary carbohydrate	primary prey	avoided prey
Arara	sweet potato	monkeys	deer tapir disliked
Parakana	bitter manioc	tortoises	deer monkeys cracids and macaws
Arawete	corn	large birds	deer tapir disliked
Mayoruna	sweet manioc	peccaries	Approximately 12–16 prey types including snakes, felids, anteaters, coatis, various monkey and bird species, squirrels, etc. Deer were probably avoided pre contact

terrestrial game. The emphasis on land tortoises in the diet was further confirmed by examination of an indigenous rubbish dump at Bom Jardim. I counted 313 largely intact tortoise shells as well as innumerable shell fragments.

However, when family groups left the village to go on hunting treks in the forest (as they frequently did), hunters stated very emphatically that treks were undertaken with the specific intent of hunting tapir. Remains of smoked game brought back to the village confirm that the Parakana generally were highly successful in this pursuit. Tapir meat was the most common, and frequently the only, food brought back to the village after treks, often in amounts weighing 30–45 kg.

Animal species well represented in the Parakana diet tended to have notable fat stores, particularly at certain times of year (Speth & Spielmann 1983). For example, in March 1986, I estimated that tapirs had a layer of fat greater than 2 cm thick beneath the skin. I observed the Parakana eating chunks of tapir and paca fat, and they are reported to take fish fat, mix it with farinha (manioc cereal) and eat this. Informants stated that the Parakana had been observed to gorge on tapir fat and meat to the point of illness.

The Parakana also eat insects, particularly palm larvae which are a rich source of fat. Analyses show fat contents (dry mass) from 35% to 69% for various types of palm larvae, which also tend to be high in protein (range 22–39% dry mass (K. Milton, unpublished data)). When living as hunter–gatherers in the forest, animal fat may have been particularly important with respect to calories for the Parakana, as wild plant foods may at times have been scant. Clastres (1972) noted that the non-horticultural Guayaki actively cultivated palm larvae at sites throughout the forest, such that this energy-rich dietary resource was available to them throughout the year.

The Arawete were the only group I worked with who kept no dogs, nor did they like or desire them. Perhaps related to this, much of their hunting activity resulted in large game birds such as moutons (*Crax fasciolata*, *Mitu mitu*), jacoos (*Penelope jacquacu*), macaws (*Ara macao*, *A. chloroptera*, *A. ararauna*, *Anodorhynchus hyacinthius*) and toucans (*Ramphastos tucanus*, *R. vitellinus*) (table 2). The Arawete village was densely populated by pet macaws of the above-mentioned species, as well as many smaller hook-bills.

As shown in table 2, the Arawete also ate a variety of other prey items including numerous land tortoises as well as agoutis and monkeys. De Castro (1986) regards tortoises, particularly tortoise liver, as the most preferred animal food of the Arawete. He also notes that the Arawete possess some 45 classifications for types of honey.

Although the Mayoruna ate a range of prey species, hunting returns show a focus on wild pigs (*Tayassu* spp.) and certain of the larger monkey species (table 2). Wild pigs were taken more frequently and consistently by the Mayoruna than by any of the other three groups; of the 25 pigs killed, 19 were collared peccaries (*T. tajaca*) and six were white-lipped peccaries (*T. pecari*). Although only one tapir was killed during my study, the Mayoruna stated that tapir was an important and preferred prey species.

The Mayoruna were the only group I saw eating sloths (*Choloepus* sp.); they stated that sloths were one of their most preferred foods. Sloths are captured by climbing their tree, lassoing them with a noose made of vines, pulling them free and then clubbing them to death on the ground. Other game is secured with bow and arrow. Fish were also important in the Mayoruna diet (table 2). The Mayoruna had been at Lobo for over nine years and stated emphatically that 'they would never run out of game' in this locale though eventually 'they might have to travel longer distances to secure it'.

(*d*) *Variation in avoided prey*

The three Pará groups had few prey restrictions (see table 3). None of them apparently ate deer before European contact. Deer were stated to be avoided because they lacked fat reserves and also 'were spirits'. Before European contact the Arara also avoided tapir as food; it was said to be undesirable, 'strong' meat. Ross (1978) notes that the Achuara consider deer and tapir to be reincarnated spirits; eating tapir is also believed to cause a skin rash. Before European contact the Parakana did not eat any monkeys or deer (most still do not), and largely avoided eating larger birds such as macaws (*Ara* spp.) and moutons (*Crax* spp., *Mitu* spp.). The Arawete dislike tapir meat, although apparently they will eat it.

In contrast, the Mayoruna had an extensive number of avoided prey. This list consisted of 12–16 different prey types, including snakes, porcupines, squirrels, felids, parrots, macaws, anteaters (two species), tyras, capybaras, coatis and various monkey species including capuchin monkeys and uacaris; adult Mayoruna do not eat howler monkeys although children do. The Mayoruna also stated they would not eat fish without scales or insects other than those found on the human body. Some Mayoruna were observed to eat deer but the antiquity of this practice is unknown.

6. DISCUSSION

(*a*) *Factors related to dietary differences*

Certain broad and obvious environmental differences between regions appear to affect the dietary pattern of their indigenous inhabitants. The Mayoruna, for example, live in an area lying outside the ancient and heavily weathered Guianan and Brazilian shields (Lathrap 1970). Climatic data confirm high and relatively uniform rainfall, and forest samples confirm a high and relatively even diversity of tree types per unit area. High primary productivity and less dominance by particular plant groups should result in a diverse and high faunal biomass which, in turn, should be reflected in the dietary pattern of the Mayoruna.

Among the Mayoruna, prey choice was more specialized than in other groups as hunters generally were able to secure large and highly preferred prey species. Conversely, in Pará the return on large game was low and less even than the return on small game (table 2). Prey selection by Mayoruna appeared similar to that of the Waorani, who live in a productive lowland forest region in eastern Ecuador. Large monkeys, peccaries and large birds make up the highest percentage (seven species compose $> 53\,\%$) of Waorani kills (Yost & Kelley 1983). Further, in striking contrast to the three Pará groups, the Mayoruna had an extensive list of avoided prey. Although sweet manioc was their most important crop for calories, the Mayoruna also routinely consumed large quantities of bananas, so much so that, in effect, they came close to having two primary carbohydrates. In contrast, the Pará groups were more narrowly focused on a single carbohydrate crop. Overall, the Mayoruna showed a narrower prey focus and a broader crop focus than other groups considered in this study, a pattern that appears related to their generally more productive environment.

Yet beyond such very general and obvious environmental differences, none of the environmental factors I examined appeared sufficiently distinct to explain most of the dietary differences observed (although, certainly, future research on this question may provide new data to alter this view). *A priori*, based on present data, in terms of the physical environment, it seems probable that any one group could successfully cultivate the primary carbohydrate crop of another. In contrast to this view, Balée (1989) has suggested that intensive corn cultivation by the Arawete is made possible by the presence of unusually fertile *terra preta* soils in their geographical region. In my view the success of the Arawete as corn cultivators does not stem from the patchy presence of *terra preta* soils in this region, but rather from the Arawete habit of clearing large new fields for corn cultivation each year, a labour-intensive endeavour, particularly before the acquisition of steel tools.

It is also difficult to determine why each group focused on (or avoided) somewhat different prey types (for discussion of this loaded topic see Sahlins 1976; Ross 1978; Harris 1987; Vayda 1987). For example, I can find no environmental reason why the Parakana do not eat monkeys. They have lived in Pará for centuries, a state in which monkeys are abundant. It is difficult to argue that the heavy, broad arrows of the Parakana preclude or make difficult the hunting of monkeys, as the arrows of the Arawete seemed almost identical to those of the Parakana, yet the Arawete focus much of their hunting on birds and also eat some monkeys. Deer and tortoises occur in the supplying areas of all four groups and yet deer were avoided whereas tortoises were eaten. The Parakana and Mayoruna strongly desire tapir meat, whereas the Arawete and Arara find tapir meat barely edible. The Arawete specialization on large birds could indicate that birds are unusually abundant in their area; it could also indicate that the Arawete preferentially hunt birds or that there are few other prey types. Having corn as a year-round staple may reduce their need for protein from game. A better understanding of environmental effects on patterns of prey selection could be obtained through censuses to determine the relative densities of different prey types in each group's supplying area.

The different prey choices and dietary habits of each group appear in large part to reflect features of their origins, history and experience in combination with present-day ecological constraints. Although recognizing that explanations of foodways are generally neither simple nor clear-cut (see, for example, Sahlins 1976; Vayda 1987; Harris 1987), I can find no compelling environmental reason why any one group could not behave dietarily in ways more similar to another if it so desired. These different dietary practices appear to reflect, as do the distinctive facial perforations and body decorations of each group, a type of cultural character displacement in which the members of group A seek to differentiate themselves from members of group B or C by means that are distinctive but do not pose any actual economic disadvantage. As Rozin (1976, p. 65) has noted, dietary customs help to define cultural and social categories and draw distinctions within and between groups. Indeed the Indian name possessed by these groups typically translates into the 'true' or 'real' people, with outsiders described as not quite human (Birket-Smith 1965). Similarly, Bahuchet *et al.* (1990), in discussing the different agricultural strategies found among four non-Pygmy groups in the Lobaye forest, comment 'by investing with cultural values one or more plant species within their food system ... each of these contiguous groups affirms its own ethnic identity' (Bahuchet *et al.* 1990, p. 33; see also Dwyer 1986; Johnson & Baksh 1987).

(*b*) ***Returning to the monkey model***

Data presented above show that forest-based groups in the Amazon Basin have many dietary differences. Despite these differences, human groups in these forests do not live sympatrically; rather, allopatry is the decided norm. Sympatric monkey species often show notable differences in details of their dental and digestive morphology and physiology (Milton 1981). These adaptations appear to function such that each monkey species can dominate a particular subset of the available dietary resources (Milton 1981; Terborgh 1983). Data suggest that, not infrequently, these interspecific differences are sufficiently pronounced such that successful invasion of one monkey species into the dietary niche of another may not be possible (Milton 1981).

This is not the case for human groups. Basically, all humans have the same digestive morphology and physiology, as well as the same need for high-quality dietary resources (Milton 1987). Humans in tropical forests meet their dietary needs with a wide range of food items, but food choices tend to follow a common theme, that of using plant foods to meet most energy demands and animal foods to satisfy most protein demands. Humans may form into discrete social units with particular dietary customs and term themselves 'the people', they may decorate their faces and bodies with specific group symbols but, unlike members of different monkey species, no human group is immune to dietary invasion by members of any other group and the immediate adaptation of any and all aspects of its subsistence behaviour that seem desirable to the invaders. Through the adaptive mechanism of culture, all human groups are actual or potential occupants of the same dietary niche.

However, this fact alone does not appear sufficient to explain the allopatry and general xenophobia characteristic of these forest-based groups. Rather, such behaviour suggests that some essential foods in the tropical forest may be distributed in patterns that set limits to viable population size (greater or lesser, depending on features of forest productivity at particular sites). An increase in human biomass in a given supplying area might therefore overtax local dietary resources or make their acquisition prohibitively costly (central place foraging, for example, sets an upper limit on viable day range).

It could be argued that these different dietary habits could serve as mechanisms to facilitate spatial overlap by different forest-based human groups, and that in the past more intergroup overlap might have prevailed. There seems little evidence, either historical or recent, to support this assumption. Not only do present-day groups show a high degree of intolerance for individuals of other linguistic backgrounds, but there is frequently considerable hostility between groups speaking the same language (see, for example, Arnaud 1983; Balée 1984; K. Milton, personal observation). Roosevelt (1980, p. 35) has remarked specifically on the possibility of pre- and post-contact local and regional population pressures on subsistence resources. As she notes, the frequent association of female infanticide, polygyny and warfare suggests the existence of a self-reinforcing system of population control. Mechanisms of population control suggest that particular supplying areas may at times approach the limits of their carrying capacity (Roosevelt 1980).

Before horticulture, forest-living groups presumably relied on wild plant foods for much of their caloric intake (see, for example, Milton 1984). Advantages for human populations utilizing plant foods, rather than meat, as an energetic substrate are discussed in Milton 1984 (pp. 19–20). In a remarkable recent paper, Dwyer & Minnegal (1990) suggest that the present-day hunting patterns of the Kubo in lowland rain forests of New Guinea relate not to present-day horticultural practices but rather to distribution patterns of their pre-horticultural carbohydrate staple, sago palms (*Metroxylon* sp.). Similarly, the Guaja Indians of Brazil have lived for many generations as nomadic hunter–gatherers (FUNAI archives, unpublished report). An informant who lived with one Guaja group for 14 months after first contact stated that their travel patterns revolved around stands of babaçu palms, the mesocarps and kernels of which provided the bulk of their intake with respect to calories. Spacing patterns of human groups in the tropical forest might, therefore, have evolved initially to protect access to limited and highly desirable caloric supplies of wild plant foods. Once horticultural practices were adopted, protection of wild carbohydrate foods should not be critical. However, with the adaptation of horticultural practices, population size of hunter–gatherer groups presumably increased, as a result of improved and more reliable caloric returns (see, for example, Milton 1984). Pressures on prey resources may then have intensified to provide protein and animal fat for this greater human biomass. Thus, unless these present-day spacing patterns and avoidance behaviours are historical artifacts, it seems likely that the efficient utilization of patchily distributed game resources may be involved. The addition of extra-group hunters into a given supplying area could reduce the resident group's hunting returns, either through disruption of traditional patterns of in-group land use (which could lower prey capture rates or increase temporal or energetic expenditures involved in hunting) or by actually lowering the amount of prey available to in-group hunters. Greater knowledge of relative prey abundances and renewal rates as well as details of hunter movements over their total supplying area for one or more annual cycles would help to test these possibilities. Local group size, prey sharing networks and day range are critical factors that must be kept in balance with the carrying capacity of each supplying area (Dwyer & Minnegal 1990).

All of the various considerations discussed above make it clear that single factor hypotheses are unlikely to suffice in explaining the dietary and other ecological practices of Amazonian forest dwellers. Rather, in the future, considerably more attention should be paid to historical factors (such as linguistic affiliations, demographic shifts, migration patterns and differential access to new crops), local environmental conditions (particularly detailed faunal surveys) and general patterns of inter- and intra-group cultural dynamics.

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Discussion

C. D. KNIGHT (*Polytechnic of East London, U.K.*). Could the author speculate on the reasons for the widespread avoidance of deer meat? The ingroup–outgroup logic would not seem applicable in this case, as all four of the cultural groups – in addition to many others – evidently avoid eating deer.

K. MILTON. This is a question that many anthropologists have tried to answer. In the tribes I worked with, the answer given for not eating deer meat was that deer were spirits and that deer lacked fat. The fact that deer meat is so widely avoided by so many different indigenous groups suggests that it may be an ancient avoidance. A discussion I had with Dr P. Dwyer has suggested a possible explanation for the widespread avoidance of deer meat. If we assume, as I believe, that indigenous groups in Amazonia were living in these forests well before the arrival of horticulture, there must have been periods each year when calorie-rich wild foods were relatively scarce. At such times, given the limitations of human physiology in terms of catabolizing amino acids for energy (Speth, this symposium), humans should have been particularly interested in seeking out foods containing either fats or carbohydrates to provide the calories they required each day. During these periods, lean meat offering little other than amino acids may have been avoided; gradually such seasonal avoidance may have developed into a general avoidance of deer as food. Bear in mind, however, that many of these food avoidances can be more apparent than real. In times of protein shortage or with moderate access to energy-rich wild foods, there may in fact be some means of relaxing this avoidance such that some or all members of the group can consume deer meat.

I. CROWE (*23 Lockhart Close, Dunstable, Bedfordshire, U.K.*). Given the primary carbohydrates mentioned were all species introduced into the forest (mainly from elsewhere in the New World), how reliable were the plant resources previously exploited, and were there any attempts to encourage propagations?

K. MILTON. Indigenous peoples routinely disperse seeds of some forest species, for example *Inga* species and species of Palmae, in areas where they settle, but there is no way of knowing whether this practice is generally deliberate of accidental. Balée, for example, has suggested that at least 11.9% of the terra firme forests of the Brazilian Amazon are anthropogenic (Balée 1989). In terms of wild carbohydrate foods, I did a survey of the availability of ripe palm nuts of the babaçu palm, *Orbignya* sp. at various locales in Pará, and found these nuts to be available throughout the year. Seeds of *Phenakospermum guianensis*, the banana brava plant, are stated by indigenous informants to be available throughout the year, but I did not do any phenological surveys of this species. I would predict that certain other palm species, *Ficus* species etc., likewise produce fruit for most or all of an annual cycle. At least three edible wild roots, two small, in clusters and more like potatoes (identified as members of the Marantaceae and Araceae; *Dracontium* cf. *longipes* Engl.) and one very large root the size of a basketball, were shown to me by the Mayoruna. The large root in particular was stated to have been eaten before horticulture and still to be eaten occasionally. I would imagine that these are in the forest throughout the year, but their relative abundances per unit area or renewal rates are not known.