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MANIOC AND FISH: A "METHIONONIAN" COMPROMISE IN AMAZONIA?

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Protein as a limiting factor in Amazonian diet has met with considerable discussion and argument (e.g., Beckerman 1979; Chagnon and Hames 1979; Johnson 1982; Gross 1975, 1982; Spath 1978, 1981; Werner et al. 1979). The intent of this paper is to continue the discussion of protein as a limiting factor in Amazonia with respect to two dietary staples, manioc and fish. More specifically, does bitter manioc become a factor in determining aquatic resource utilization in Amazonia?

Current anthropological literature concerning subsistence strategies in Amazonia is growing rapidly and will continue to expand with publication of available quantified data. Until that time, however, a complete view of Amazonian subsistence can only be seen in the work of Murdock (1951) and Steward (1963). Murdock's Outline of South American Cultures and Steward's Handbook of South American Indians provide at this time the only unified works. The volumes, to say the least, are sketchy summarizations of past fieldwork and descriptions of Amazonian tribes. Nonetheless, these two guides will be utilized in this study to focus on the two food resources of bitter manioc and fish and to determine whether a high reliance on bitter manioc will be associated with a high reliance on aquatic resources.

The mise en scene of this relationship is that bitter manioc, a root crop that produces a high amount of starch for the diet, must be met with a complement of high protein in order to provide an adequate diet. Complications, however, do exist that may take the relationship more meaningful.

Bitter manioc, a high yielding root crop with relatively :
labor input, is a staple throughout areas of Amazonia. The to:
of the cultigen to various environmental conditions is greater
that for most domesticated plants. It is storable if made intc
or cakes. The root, however, is intolerant of water-logging, a
is "suspected not to be able to use soils of exceptional high f
tility" (Roosevelt 1980).

The toxic residues that remain in bitter manioc and its lc
protein content of the root are important in this study. Cyano
glucosides are found throughout the plant, and prior to ingesti
these compounds must be eliminated through processing technique
The prussic acid produced by the axidation of cyanogenic glucos
in the root when they are harvested is extremely volatile and m
be driven off by any one of several simple known techniques suc
as washing, sun-drying, heating, or fermentation. "Some tribes
it off by heat, others by exposure to the sun. One or more of
methods is practiced by all peoples who use bitter manio as foo
(Dole 1956:241, 244.).

After processing, however, low levels of the cyanide remai
the food and in the diet. In order to detoxify the remaining c
certain amino acids must be present above minimum requirement l
in the diet. Spath (1981) indicates that "the metabolism of lo
levels of cyanide utilizes and may deplete cystine and methioni
in the blood." Cystine and methionine, being sulphur based ami
acids, detoxify the cyanide by a reaction with thiosulfate, a b
product of methionine. With a shortage of detoxifying amino ac
or with a reduced intake of amino acids, detoxification can lea

to an irreversible degeneration of the peripheral nerves and other symptoms of tropical ataxia. Eliose Berlin (1978) gives a historical account of Tropical Ataxia Neuropathy (TAN) and cassava consumption. Berlin concurs that high cyanide intake increases sulphur-containing amino acid requirements. Lathrap (1970) believes that where a "manioc-based diet is not supplemented with animal protein, the protein deficiency, Kwashiorkor will be common and a major source of child mortality."

Manioc is a productive calorie source; however, the products of manioc roots cannot provide for a balanced diet on their own. Manioc must be supplemented with high quality protein (Roosevelt 1980). Gross (1975) believes that manioc, although it provides the bulk of Amazonian diet, "cannot begin to meet the average individual's requirement for dietary protein because of its low protein conent." Spath (1978:) states that

> protein malnutrition with a diet based strongly on manioc is more acute than the general problems of protein capture in the tropics...because to avoid small increments of permanent damage to the nervous system, the individual must consume sufficient quantities of methionine every day. It is preferrable for adequate quantities of methionine to be present in the body prior to the consumption of manioc.

One would expect that clumped and predictable animal resources must exist in the environment and they must be taken advantage of in a consistent fashion. Regular and reliable protein capture would be extremely important. Spath (1981) stresses that minimum levels of critical nutritional elements is more important to adaptation than mean or maximum availability.

If manioc must be supplemented with high quality protein, other resources are adequate in supplying this need on a regula reliable basis? Crops such as maize and beans, which could pr additional vegetable protein, cannot adequately be produced on same types of soils as manioc (Roosevelt 1980). Beckerman (19 suggests that even though there is a wide variety of plants, i and even protozoan sources of protein in the tropical forest, today concentrate on fish and game. He gives an immediate ans that "there's enough meat to go around." He (1979:) contin to give a more serious explanation that covers the following po

> 1) Meat...has protein of the highest quality of any food. It contains just what we need for our own tissues in just the right proportions. Furthermore-perhaps for precisely those reasons-it tastes good!
>
> 2) In the absense of meat, the amino acid combination necessary for adequate human protein intake can be mimicked by vegetable proteins...However, vegetable proteins are, in general, less concentrated and less well balanced than animal proteins.

Berlin (1978) concludes her historical review on TAN and c consumption by citing Spath (1971:) that "... on the basis o the high sulphur content of fish, set forth the hypothesis that toxicity of manioc was the determining factor in settlement pat (i.e., along waterways) in South America." In other words, gro that are dependent upon manioc as a staple of the diet, settle close as possible to waterways in order to make use of the high sulphur content of aquatic resources.

The formulation of this hypothesis by Spath serves as the for this research paper. Does high reliance on the toxic strai of manioc necessitate the exploitation of high sulphur content

resources? Quantifiable data must be available for the extensive number of groups living and subsisting in the Amazon in order to answer this question. At this time, sufficient data is not available, and it is the assumption of this researcher that it may not be available for some time due to the political and industrial nature of the world today. Nevertheless, it may be plausible that, with past and current information, a re-analysis of this hypothesis, may lead to the discovery of it being valid or invalid.

It is first necessary to look at the nutritional deficiencies that limit the dietary functions of manioc for humans. Table 1 describes the contents of manioc in comparison to maize. Protein and fat constitute an extremely small proportion of the contents of manioc roots. Protein calories make up less than 2% of every 300 calories produced in the root, and the quality of the protein is low, being deficient in the sulphur-bearing amino acids and tryptophan. Ascorbic acid and calcium and the only vitamins and minerals present. The low protein content of manioc seriously limits the part that it can play in human nutrition, despite the plant's great productivity.

Compared to dry whole kernel yellow maize, manioc expresses its deficiencies. Manioc is a high yield crop per hectare with regards to protein/mass, whereas maize is higher in proportion of protein in seeds. However, when manioc is processed into a flour, to be used for bread (cassava) the caloric content is increased from 148 calories per 100 grams to 320 calories per 100 grams of flour. Other contents are also increased, but the amount of ascorbic acid and Vitamin A is decreased.

Table 1. Contents of 100 gm Edible Portion of Ray Manioc Roo and Dry Whole Kernel Yellow maize[a].

	Manioc	Maize
Food energy	148 calories	361 calori
Moisture	60.6%	10.6%
Protein	.8 gm	9.4 gm
Fat	.3 gm	4.3 gm
Carbohydrate	37.4 gm	74.4 gm
Fiber	1.0 gm	1.8 gm
Ash	.9 gm	1.3 gm
Calcium	36.0 mg	9 mg
Phosphorus	48.0 mg	290 mg
Iron	1.1 mg	2.5 mg
Retinol	---	5 micgm
Vitamin A Value	5 micgm	70 micgm
Thiamine	.06mg	.43mg
Riboflavin	.04mg	.10mg
Niacin	.7 mg	1.9 mg
Ascorbic acid	40.0 mg	trace

[a]From Wu Leung and Flores 1961:13, 25.

Table 2 compares the amino acid content of manioc, maize, and eans. The amino acid cystine exhibits nearly equal levels in anioc and maize, yet it is somewhat lower in beans. Methionine evels in manioc are considerably lower in beans. Methionine evels in manioc are considerably lower than that of maize, but igher than that of beans. Tryptophan is highest in the bean, and anioc is higher than maize in that amino acid. These considera-ions become important. "It is now recognized that mixtures of cer-ain plants provide a perfectly adequate source of protein for dult human diets? (Roosevelt 1980:140).

oil conditions for the three cultigens vary. Whereas maize is specially well-suited to cultivation in high-nutrient river bottom and, and in combination with beans, can furnish a balanced diet ackage, manioc will become waterlogged if left to remain for a onsiderable period of time after the flood waters have receded. Ianioc cannot compete "with the seed crops in efficiency of exploi-ation of alluvial bottom land" (Roosevelt 1980:139).

Manioc and maize mixtures will not provide adequate amino cid combination because of the lack of tryptophan in both plants. he products of the manioc root must be eaten with high-quality rotein, animal flesh to avoid protein-deficiency diseases.

If high protein animal flesh is not adequate in the diet, the mino acid methionine, along with cystine, will be reduced to far elow the minimum requirement of human protein consumption. Along ith the prussic acid digested with manioc products. If insufficient mounts of the sulphur amino acids and high prussic acid level haracterize the manioc diet, ataxia could result. Coursey and ooth (1977:81) urge "that Cassava must be regarded essentially as

Table 2. Amino Acid Content of Manioc, Beans, and Miaze[a,b]

Amino Acids	Manioc	Beans	Maize
Arginine	683	355	262
Cystine	90	53	97
Histidine	129	170	177
Isoleucine	175	262	230
Leucine	247	476	783
Lysine	259	450	167
Methionine	83	66	120
Phenylalanine	156	326	305
Threonine	165	248	225
Tryptophan	72	223	44
Tyrosine	100	158	239
Valine	209	287	303

[a]From FAO 1970:46-47, 90-91, 38-39, 50-51.

[b]In milligrams per gram of nitrogen.

an energy source and, whenever possible, be supplemented with rich foods."

Table 3 lists grams of protein per 100 calories for selected foods. Manioc (cassava) produces 0.8 grams of protein, maize 2.6 grams, lean beef 9.6, fish 10.2-21.0, and fish flour 22.0-23.0. Given the low protein content of manioc, and fish and fish products would be most beneficial in tropical diets (cf. Table 3).

Borgstrom (1962) points out that the value of a meal containing mainly vegetable proteins can be greatly improved with the addition of fish protein. Fish protein contains ample supplies of the amino acids lysine, methionine, and to a lesser extent, cystine, isoleucine, and treonine. Borgstrom (1962:81) points out that when fish is prepared as a flour product, its supplementary value in the diet "is excellent ... in all areas of the world where protein malnutrition is prevelant."

Fish protein, then, may become a significant factor in manioc-based diets. The amino acids methionine and cystine, limiting in manioc, are found in fish (methionine in a higher degree than cystine.)

It is with this information in hand that the "fieldwork" will begin. Figures 1 and 2 provide a foundation for the following analysis. The figures reflect information compiled from Murdock (1951) and Steward (1963). The common factor in Figure 1 is that all groups rely to an extent on manioc, either bitter or sweet. The symbols plus (+) and minus (-) indicate that there is a high reliance (staple) on manioc or a low reliance (low) on manioc. Moderate indicates that manioc is present in the diet, but subordinate to another plant staple.

Table 3. Grams of Protein in 100 Calories of Selected Foods[a]

Food	g/100cal
Manioc (cassava)	0.8
Banana	1.0
Sweet potato (*Ipomoea batata*)	1.1
Rice (white milled)	1.7
Taro	1.7
Maize (whole meal)	2.6
Cow's milk (3.5% fat)	5.4
Hens egg	7.9
Beef (lean)	9.6
Skim milk	10.0
Nonfat milk solids	11.3
Fish, fatty	10.2-13.2
Fish, lean	15.0-21.0
Fish, dried	21.8
Fish flour (extract)	22.0-23.0

[a]Borgstrom (1962:283)

The dependent variable in Figure 1 is "Fish." The symbols plus (+) indicate that there is a high fish. The minus (-) indicates that there is a low reliance on fish in the diet. Moderate indicates that fish is present in the diet, yet is secondary to hunting.

The determinations of manioc or fish reliance are somewhat qualitative. Murdock and Steward to not provide percentages for subsistence. Qualifications such as "insignificant," "more important", "both hunting and fishing", and "not present" become indicators for the figures. Table 4 presents the common terms used by Murdock and Steward.

Chi Square tests were utilized based on data from both Figure 1 and Figure 2. Table 5 illustrates the results. The results based on Figure 1 data, the relationship among Amazonian groups using manioc and fish, show that the probability of chance is greater than 0.05 (;= 0.2957).

Table 5 indicates that there is perhaps a closer association for the use of bitter manioc and fish, than expressed in manioc and fish. However, the probability of chance is still greater than 0.05 ($p = 0.0512$). It should be noted that $p > .05 < .10$.

These results illustrate that "there is no significant difference" however, it becomes interesting to note the greater movement to "significant difference" between the two figures. Figure 1 included groups that utilized manioc (bitter and sweet) within the diet. Figure 2 included groups that utilized just bitter manioc within their diets. It may be assumed that when bitter manioc

Table 4. Interpretations of Qualitative Terms given to Subsist
Strategies.

Qualitative Term(s)	Represented in Figure as:
"Little importance" "Insignificant" "Almost no..." "Of little consequence"	- (Low)
"Some..." "Bitter and sweet" "Hunting and Fishing" "...secondary to..."	Moderate
"More important" "Live mainly..." "Staple is..." "Subsist primarily..."	(+) (Staple)

Figure 1
Relationship Among Amazonian Groups Using Manioc and Fish

	– Low	Moderate	+ Staple
+ Staple	8	8	26
Moderate	1	8	25
– Low	4	4	9

MANIOC

Figure 2
Relationship Among Amazonian Groups Using Bitter Manioc And Fish

	– Low	Moderate	+ Staple
+ Staple	0	3	21
Moderate	0	2	5
– Low	1	2	2

Bitter Manioc

Table 5. Chi Square Results From Figure 1 and Figure 2.

Figure:	Chi Square Results:
1 - Manioc and Fish (T=97)	p = 0.2957; reject at
2 - Bitter manioc and Fish (T=36)	p = 0.0512; reject at

s the primary staple in the diet, fishing may become the important ource of protein. The test should be viewed with a certain amount f skepticism since the numbers and categories are subjective and ere derived from information that is sketchy and unquantified. lso, these chi square tests which involve more than 3 degrees of reedom and exhibited expected frequencies less than 5 violate the asic requirements of this statistical test.

The results, on the other hand, may be used as the basis for a ypothesis which anticipates a direct relationship between reliance n bitter manioc and use of fish in the diet. In order to determine f there is any relationship, case studies will be examined of ecent field data collected in Amazonia. Table 6 presents the boriginal groups, researcher, publication source, and date. Other tudies which were not available may present additional information. he studies utilized do not reflect any similar method of data tabuation. Data quality ranges from good quantifiable to "a bit less ketchy" when compared to Murdock and Steward. More recent research eflects the more adequate information.

Once the research has been assessed, on a case by case basis, summary of the information, projections for further research, nd conclusions will be the final concerns of this paper. Research ssessment will not indicate acceptance or rejection of the ypothesis as stated. Therefore prior to assessment of current ata, a null hypothesis will be formulated.

The null hypothesis is: There is no significant difference n the use of fish as a staple protein supplement among Amazonian

Table 6. Recent Research Utilized in Assessing Manioc/Fish Hypothesis

Researched Group	Researcher	Publication/Date
Kuikuru	Carneiro	Man in Adaptation "The Cultural Present" 1968:1
Yanomamo	Chagnon	Yanomamo, The Fierce Pe 1968
	Chagnon & Hames	Science 203(4383):910-91 1979
Bororo Kanela	Gross et al.	Science 206(4422):1043- 1979
Mekranoti Xavante	Flowers et al.	Human Ecology 10(2):203- 1982
	Werner et al.	Human Ecology 7(4):303-3 1979
Machiguenga	Johnson & Behrens	Human Ecology 10(2):167- 1982
Munducucu	Murphy	Headhunters Heritage 196
Camayura Jivaro Kayapo Omagua Siriono Waiwai	Meggers	Amazonia Man and Culture a Counterfeit Paradise 1
Yanomami	Lizot	Man 12:497-517
Jivaro	Berlin & Berlin	Studies in Aguarana Jiva Ethnobiology Report 1, 1
	Harner	The Jivaro 1973
	Ross	The Achuara Jivaro, PhD d sertation 1976
Siona-Secoya	Vickers	Cultural Adaptation to Amazonian Habitats: The Siona-Secoya of Eastern Ecuador, PhD dissertation 1976.

groups that rely on bitter manioc as a primary or secondary source of vegetable subsistence.

Carneiro's fieldwork of the Kuikuru of Central Brazil was carried out in 1953-54. The tropical forest society occupied an area near the Kuluene River, a headwater tributary of the Xingu River. The one village researched is situated in an extensive forest tract.

The most important crops, according to Carneiro, are 11 varieties of manioc (*Manihot esculenta*) and all of the varieties are poisonous. The cakes of manioc make up approximately 80-85% of the diet. Fishing accounts for the remaining amount of the diet with hunting providing less than 1% of the food supply. Fish, then, is a major source of protein used to balance the deficiencies of bitter manioc.

Chagnon's fieldwork among the Yanomamo was carried out between 1964 and 1968 on various trips (as of the 1968 publication). The groups live in southern Venezuela and portions of northern Brazil. The villages studied lie in an area close to the Mavaca and Orinoco Rivers. Most Yanomamo villages are located at elevations of less than 3000 feet above mean sea level.

Plantains and bananas, along with sweet manioc are indicated as the major garden staples. However, bitter manioc has recently been an addition introduced by missionaries. Fishing comprises about 33% of the animal protein capture (Chagnon and Hames 1979:911) estimated from the grams protein per capita per day in Yanomamo animal protein consumption. Fish then is of secondary importance to the Yanomamo, at least when compared to animal protein derived from hunting.

Gross, Flowers, Werner, et al. studied the Bororo, Kanela, Mekranoti, and Xavante Indians of Central Brazil. With the ex tion of the Mekranoti, the groups inhabit the "cerrado" area. The Mekranoti and the Kanela, bitter manioc is the staple crop the Bororo and the Xavante it is upland rice (Flowers 1982:206 though manioc is included in the garden subsistence.

The authors do not give any quantifiable data with regard protein procurement from hunting or fishing, but they do give allocations. Within a total animal protein capture (Werner 19 it is calculated that the Mekranoti protein capture for fish is of the total animal capture. Animal protein capture for the K is also 19% with regards to fish. For the Xavante, 48% of tota animal protein capture is fish and for the Bororo 84% of the to protein capture is fish. The Bororo, however, sell part of the fish catch and the same is true of the Xavante.

The two groups that rely the most on bitter manioc, the Mekranoti and the Kanela, have the lowest percentage of fish in the total animal protein intake as compared to two groups, the Xavante and Bororo.

The Machiguenga inhabit the tropical rain forest of south-eastern Peru, situated primarily on the Urubamba River and exte into the headwaters of the Madre de Dios River. The main horti tural product of the Machiguenga is sweet manioc, producing abo 72% of the total horticultural produce (Johnson and Behrens 198 175). Fishing produces 76% of the total amount of protein from non-gardening subsistence strategies (Johnson and Behrens 1982:1

The Machiguenga diet then is very high in the amount of fish protein in the diet, however sweet manioc (*Manihot esculenta Crantz*), is the main garden product. There is no mention of bitter manioc in the diet.

The Mundurucu Indians were first researched by Murphy in 1952. The group inhabits an area on the upper Tapajos River, south of the Amazon. According to Murphy (1960:60) several varieties of bitter manioc are the staples. This information is not quantified, however. Fishing is of importance, and is primary to those Mundurucu who have moved to the shores of the larger Cururu River. However, fishing is of secondary importance in the savannah villages, where the main activity is hunting (Murphy 1960:52-56). The Mundurucu smoke, salt, and sun-dry fish, but it only remains edible for one week to ten days.

Meggers draws upon "more than twenty years of experience in the tropical lowlands of South America" (Meggers 1970:viii) in her investigation of the Camayura, Jivaro, Kayapo, Omagua, Siriono, and the Waiwai. Of these groups five, the Camayura, the Jivaro, the Kayapo, the Siriono, and the Waiwai, inhabit a *terra firme* environment, while the Omagua inhabit a *varzea* environment, one that is inundated every year.

The Camayura tribe inhabits an area on a small tributary of the lower Kuluene, and the staple food is bitter manioc which is harvested all year long. Fish are also a primary staple.

The Jivaro occupy an area of approximately 25,000 square miles, bounded by the lower slopes of the Andes on the west, the Rio Pastaza on the east, and the Rio Maranon on the south. The Jivaro staple is sweet manioc, and hunting seems to be more important than

fishing.

The Kayapo inhabit a region between the Rio Araguaya and t middle Xingu. The area has marked seasonality. The main stapl for the Kayapo is maize and sweet potato. However, European en croachment have forced the adoption of sweet manioc, rice, and bitter manioc (Meggers 1970:69). Hunting and fishing are both portant due to the seasonality. Fishing is more important in t dry season, when the lowered water makes it more productive (Meggers 1970:71).

The Siriono inhabit an area on the southwest margin of the tropical forest, between the Brazilian highlands and the foothi of the Andes. The Siriono are primarily hunters and gatherers, with fishing and agriculture secondary. Of horticultural resou maize and sweet manioc is the staple. Fishing is an activity t is done primarily in the dry season, and at that time it is a strategy of secondary importance.

The Waiwai habitat is part of the Guayana highlands, drain by the headwaters of the Essequibo and the Mapuera. The staple of Waiwai subsistence is bitter manioc. Hunting is the primary animal protein capturing subsistence. Fishing, though importan is secondary.

Inhabitants of <u>terre firme</u> vary in subsistence strategies. The <u>varzea</u> is also a variable environment. It, however, is cha terized by differential inundation (Meggers 1970:121). The Oma culture as revealed by Meggers, is one of the past. Quoting Carvajal (1934, 1942) the subsistence of the Omagua was a high liance on bitter manioc, with maize also being of importance. Fishing was a major subsistence resource and was practiced on a

daily basis (Meggers 1970:127).

Lizot (1978) studies two groups of the Yanomami, Karohi and the Kakashiwe. Formerly, according to Lizot, the Yanomami "occupied a territory bordering on the main tributaries of the Upper Amazon, where the Rio Negro and Rio Branco meet" (Lizot 1978:499). Today, however, less than 10% of the population live along the banks of navigable rivers. The Yanomami depend on banana plantain for nourishment, which consists of 72% of the Karohi diet and 85% of the Kakashiwe diet, as far as agricultural resources are concerned. Fishing for the Karohi produces 12% of the total weight of animals consumed, and for the Kakashiwe fishing contributes nearly 13% of the animals consumed. Both calculations are given for consumable parts only (Lizot 1978:509).

The Jivaro have been studied by various researchers, Berlin and Berlin (1977), Harner (1973), and Ross (1976). Harner gives a report of the entire Jivaro area including the tribes of the Jivaro (untsuri suara). The Achuara, Aguaruna, and the Huambisa, while Ross studied the Achuara, and Berlin and Berlin studied the Aguaruna. The Achuara are a tropical forest population who inhabit the region bounded by the Pastaza and Morona Rivers. Most Achuara live on smaller inland streams where "fishing by small Achuara communities is year-round and rather productive" (Ross 1976:145). Fishing contributes 5.7% to the bulk of the diet, yet 26.4% of daily protein per capita, and when comparing just hunting and fishing, fish protein contributes 33.6% of the diet (Ross 1976:149). Manioc contributes 53.09% of the raw harvest total. Ross makes no distinction as to whether it is bitter or sweet, however, other reports indicate

that it is the sweet strain.

Berlin and Berlin study the Aguaruna Jivaro who occupy an area of dense tropical rain forest in the Department of Amazon Peru. "They are one of the largest tribes in the republic's lowland jungle" (Berlin and Berlin 1977:2). Sweet manioc is t staple but plantains and bananas are also important. "The so- bitter manioc, an ecological variant of the same species as sw manioc, is not cultivated by the Aguaruna" (Berlin and Berlin 10). Fish provides the major contribution in the procurement animal protein and provides 54.92% of total protein intake (Be and Berlin 1977:16).

Vickers studied the Siona-Secoya of Eastern Ecuador who a Western Tucanoans of the Agurico River. "The Aguarico is a no tributary of the Napo River, which in turn is one of the large more important tributaries of the Amazon" (Vickers 1976:22). T area is classified as a tropical rain forest (and reclassified tropical lowland rain forest, Vickers 1976:27). Manioc (fifte varieities including two which are poisonous) contributes 42% garden produce. Fish provides 54% of the animal protein of gr per day and 43.9% of total protein of grams per day (Vickers 1 135).

Table 7 illustrates the use of manioc and fish by the grou in the study. Looking at Table 7 it becomes quite apparent tha current research has progressed in quantitative methodology, ye descriptions can be somewhat qualitative. Nevertheless, does c rent ethnographic information indicate a reliance on manioc and fish? At first glance, the data would suggest that a randomnes

Table 7. Groups Reliance on manioc and fish

Group	Manioc	Fish
Kuikuru	80-85% bitter	high reliance
Yanomamo	both bitter and sweet	33%
Mekranoti	38% bitter	19%
Kanela	42% bitter	19%
Xavante	12% bitter	48%
Bororo	7% bitter	84%
Machiguenga	72% sweet	76%
Mundurucu	staple-bitter	low reliance-savannah high reliance-riverine
Camahura	staple-bitter	high reliance
Jivaro	staple-sweet	low reliance
Achuara	53.09% sweet	26.4% of daily protein
Aguarana	staple-sweet	54.0% of daily protein
Kayapo	both sweet & bitter as secondary	high reliance during dry season
Siriono	staple-sweet	high reliance during dry season
Waiwai	staple-bitter	of secondary importance
Yanomami		
Karohi	not noted	12%
Kakashiwe	not noted	13%
Siona-Secoya	42% (2 of 15 varieties bitter)	43.9% of daily protein

is the hallmark of the "polaroid snapshot" of Amazonia. Yet, of the eighteen groups studied utilize bitter manioc to some e tent. Five studies use quantifiable data for both manioc (bit and fish. Seven studies use quantifiable data for one of the categories. Seven studies use quantifiable data of "manioc" (either bitter or sweet) and fish.

How does this information fit into the projected model co structed previously? Figures 3 and 4 present more current dat than that utilized in Figures 1 and 2. Figure 3 shows the re tionship among Amazonian groups using manioc (both sweet and/o bitter) and fish. Figure 4 shows the relationship among Amazo groups using bitter manioc and fish. The total eighteen group accounted for in Figure 3, while only eleven groups are accoun for in Figure 4. Table 8 evaluates qualitative terms and perce used by the researchers. A "low" in both categories is a reso under 20% of the total diet. A "moderate" is over 20% and und for manioc and over 20% but under 40% for fish (in all cases h cultural resources included more than three items. In most ca the only differentiation in animal resources was fish or game) "staple" is over 35% for manioc and over 40% for fish.

Groups that showed a high reliance on manioc and fish wer Kuikuru, Machiguenga, Mundurucu (riverine), Camayura, Aguaruna the Sirionо (dry). Of these six groups, only the Kuikuru, Mun (riverine) and the Camayura have bitter manioc as a staple. Gr that showed a high reliance on manioc and a moderate reliance o fish were the Yanomamo, Achuara, and the Waiwai. Of these thre

Figure 3. Relationship Among Amazonian Groups Using Manioc and Fish

FISH \ MANIOC	- Low	Moderate	+ Staple
+ Staple	2	2	6
Moderate	1		3
- Low			4

Figure 4. Relationship Among Amazonian Groups Using Bitter Manioc and Fish

FISH	BITTER MANIOC: - Low	Moderate	+ High
+ Staple	2	2	3
Moderate			2
- Low			2

Table 8. Qualitative Terms and Percentages Used by Researchers and Values Assigned.

Percentages and terms	Assigned Value
Staple Over 40% (fish) Over 35% (manioc) High Reliance	+
Secondary Importance Sweet and Bitter 20-35% (Manioc) 20-40% (fish)	Moderate
Low reliance Not noted Under 20% (manioc) Under 20% (fish)	−

groups, only the Yanomamo and Waiwai showed a high reliance on bitter manioc. The Mekranoti, Kanela, Mundurucu (savannah), a the Jivaro showed a high reliance on manioc, but a low relianc on fish. Of these four groups, only the Mekranoti and the Kan showed a high reliance on bitter.

The Kayapo and the Siona-Secoya showed a high reliance on fish and a moderate reliance on bitter manioc. The Xavante an the Bororo showed a high reliance on fish, but a low reliance bitter manioc. The Yanomami showed a moderate reliance on fis and no reliance on manioc.

The results are perhaps not sufficient to either accept o reject the first hypothesis that "a high reliance on the toxic strains of manioc are associated with exploitation of resourc of high sulphur content." Nor is it believed by this research that there is an adequate number of cases to accept or reject t null hypothesis. However, that does not underestimate the imp tance of the problem.

If a group relies on bitter manioc as a major resource in diet, a comparable high protein supplement is required in orde prevent the high amounts of toxins in the blood. Fish are cons dered to be a high source of sulphur protein. Gross (1975:534- emphasizes the ability of peoples of the Amazon Basin to adapt tremely well to their environment:

> The most remarkable thing is that peoples of the Amazon Basin have adapted so well to an environment with relatively poor soils, few sources of animal protein, cultivated foods low in essential nutrients, and even high toxin levels in the principle staple. Perhaps the best evidence for my claim of a successful adaptation to protein scarcity is the fact that symptoms of protein deficiency disease have never, to my knowledge, been reported for relatively unacculturated tribal peoples in the Amazon region.

Carneiro (1968:245) poses the realization that,

> From a cultural-ecological point of view the Amazon Basin may be thought of as comprising two distinct types of habitats, one consisting of areas lying along the major rivers, and the other areas located away from them. These two types of habitat differ strikingly in the amount of fish and other riverine food resources which they make available for human exploitation. In the small rivers and streams of the interfluvial area, fish are relatively few in number and small in size. In such areas fishing can hardly serve as the major source of protein. In habitats of this type it is hunting, not fishing, which must be relied on for the bulk of the protein in the diet.

Because of the high yield of manioc and its ability "as an efficient producer of calories in the low-nutrient soils of upland tropical forests, making possible maximal use of scarce animal protein" (Roosevelt 1980:139), manioc can be adaptive outside of a riverine environment. Quite possible the sweet strain of manioc becomes a valuable source of calories and starch in the upland environment.

The "storability" of manioc as a source of calories in seasonal or humid tropical climates is an advantage, independent of what supplementary source of protein is available. On the other hand, "due to the perennial habit and intractable nutritional deficiencies, manioc cannot complete with the seed crops in efficiency of exploitation of alluvial bottom land" (Roosevelt 1980:139).

The advantages of manioc can be great in the Amazon Basin and the distribution of devices used in preparing manioc flour is an indicator of that (Dole 1956:243). Yet, this research indicates that its use varies along with the type of supplemental protein that accompanies it. A source of fish provides the highest amount of protein (Borgstrom 1962:283), yet varied groups have

adapted to a variety of protein-producing resources to provide adequate nutrition.

Further research may indicate that the strategies are eff cient for a group within a specific ecological habitat. Curre research has quantified much of subsistence efficiency in Amaz but few have centered on this specific problem. Spath's hypot may hold up, yet it still seems that the anthropologists are s at "square one". Figures 2 and 4 demonstrate that the relati between bitter manioc and fish, does not obtain at this stage our investigation. Quite possibly early qualitative descripti of Amazonian groups were erroneous or faulty; with further qua fied studies of diet researchers in the years to come may have ability to examine human behavior scientifically.

Results from the eighteen Amazonian groups indicate that relying on manioc (either sweet or bitter) may or may not util aquatic resources as a staple of the diet. Figures 3 and 4 in cate no significant association at the .05 level in a Chi Squa analysis. Once again, however, it should be emphasized that t analyses violate the basic requirements for Chi Square tests s for df __ 4 the expected frequencies should __ 5. Future res and analysis may reflect a stronger relationship between bitte manioc and fish consumption.

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