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AN ANALYSIS OF AMAZONIAN HUNTING YIELDS AS A FUNCTION OF SETTLEMENT AGE

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Introduction

The purpose of this paper is to focus on the aggregate hunting yields of a specific Amazonian Indian community through time. The paper relates to a controversial debate among specialists concerning the availability of dietary protein in the Amazon Basin and the significance of the protein factor in the dynamics of tropical forest societies (e.g., Beckerman 1979, Chagnon and Hames 1979, Gross, 1975, Harris 1974, 1977, Ross 1978, Siskind 1973, and Vickers 1975, 1979). Stated briefly, the major argument concerns whether or not protein availability is the major ecological factor in the cultural processes of tropical forest warfare, low population density, migration, male supremacy, and village-level political organization. Proponents of the protein scarcity hypothesis such as Harris, Gross, and Ross argue that the relatively low availability of protein in tropical forest habitats accounts for these features. Opponents of the protein scarcity hypothesis reject this position and offer a variety of competing hypotheses based on ecological, structural-functional, or mentalistic paradigms (reviewed in Vickers 1979).

The research that I have conducted among the Siona-Secoya Indians of northeastern Ecuador has led me to the belief that tropical forest culture can best be understood in terms of the interactions between a human subsistence technology based on shifting horticulture, hunting, fishing, and collecting and environmental resources. Specifically, I have argued (1975, 1976, 1979) that

protein availability is but one of a number of environmental factors which may exert a limiting influence on population density, settlement size and permanence, and political organization in the Amazon, and that a multifactorial ecological model is superior to a single-factor model. The present paper will not resolve this debate; the purpose here is to shed light on the dynamics of hunting at a specific settlement through time via the quantitative analysis of aggregate hunting yields. By design, the scope of this paper is delimited to the relationship between one independent variable (length of settlement) and one dependent variable (hunting yields). Since this paper is not intended as the definitive description of the complexities of Siona-Secoya hunting, dimensions such as hunting zone locations and characteristics, seasonality, and hunting techniques and strategies are not treated fully here. However, my omission of these details should not be taken as an indication that Siona-Secoya hunting lacks sophistication. Even though the present analysis is devoted to the relationship between two variables, it does provide insights into the structures and sizes of game populations, the impact of hunting on these populations, and changes in hunting emphasis through time. Furthermore, the focus on length of settlement and hunting yields provides empirical data which are highly relevant to the debate concerning the significance of animal protein availability in Amazonian cultural dynamics.

Location of the Study and Methods

This study focuses on hunting at the Siona-Secoya Indian village of San Pablo de Shushufindi on the Aguarico River in northeastern Ecuador. Eighteen months of fieldwork was conducted there from September 1973 through March 1975, and six weeks of subsequent fieldwork was carried out from late June through early August 1979.[1] The Siona and Secoya are related groups of Western Tucanoan speaking peoples who have intermarried and migrated to their present location on the Aguarico River from the Cuyabeno River in 1973 and from the Angusilla River (Peru) in 1974. The observations on hunting activities and yields from 1973-75, therefore, are representative of a new village in its first two years of existence; the observations from 1979 are representative of a village in its sixth year of existence. As of March 1975, a field census indicated that there were 266 Siona and Secoya residing within the borders of Ecuador. However, this population was dispersed and the number of people in specific settlements was subject to fluctuation as emigration and immigration of households occurs with frequency over the period in which a particular location is inhabited. During 1973-75 the mean number of individuals residing at San Pablo was calculated to be 132. The census update made in July 1979 indicates that the present population of Siona-Secoya in Ecuador is 316. It is estimated that the mean population of the San Pablo site in 1979 is about 160, but with considerable variation in the number of individuals present at any given time.

The methods of observation concerning hunting activities and yields included both direct observation and weighing of yields and post-hunt interviews. The observations and interviews were designed to elicit the following information:

1. The name of the hunter
2. The date of the hunt
3. The time of departure from the village
4. The time of return to the village
5. The location of the hunt
6. The species and number of animals killed, or whether no kill was made
7. The weight of each animal killed or captured (either by direct weighing or by estimation using mean weights for specific species)
8. The names of hunting companions, if any (to allow subsequent interviews concerning their yields for the hunt)

The 1973-75 fieldwork resulted in a sample of 283 individual hunts (i.e., the equivalent of one man on an average one-day hunt). On hunts of more than one day, the yield for each day was taken separately for computative purposes. It is estimated that this sample represents approximately 13% of the total number of hunts originating from the settlement during the 18-month research period. The 1979 fieldwork resulted in a sample of 148 hunts (involving 45 hunters), which is estimated to be 59% of the hunts during the six-week research period. The proportionally larger 1979 sample reflects the fact that the observation of hunting activities was the first priority of the fieldwork, whereas the 1973-75 fieldwork focused on a wider range of ecological and ethnological problems.

TABLE 1. MOST COMMON GAME SPECIES IN SIONA-SECOYA HUNTING YIELDS, 1973-75

Species	Number in Sample[a]	Estimated Annual Kill[b]	Ranking by kcal Contribution
Woolly monkey (Lagothrix spp.)	130	662	3
White-lipped peccary (Tayassu pecari)	92	468	1
Collared peccary (T. tajacu)	85	433	2
Curassow (Mitu salvini)	61	310	5
Piping guan (Pipile pipile)	40	204	9
River turtle (Podocnemis spp.)	19	97	12
Trumpeter (Psophia crepitans)	16	81	14
Spix's guan (Penelope jacquacu)	14	71	13
Tapir (Tapirus americanus)	12[c]	8[c]	4[c]
Howler monkey (Alouatta seniculus)	11	56	6
Agouti (Dasyprocta sp.)	10	51	10
Armadillo (Dasypus spp.)	5	25	8
Tortoise (Geochelone sp. or Testudo sp.)	3	15	15
Perdiz (Crypturellus sp. ?)	3	15	-
Toucan (Pteroglossus spp. and Rhamphastos sp.)	3	15	-
Cayman (Caiman spp.)	2	10	11
Capybara (Hydrochoerus hydrochaeris)	2	10	7
Deer (Mazama spp.)	2	10	-

[a]The sample consisted of 283 individual one-day hunts. It is estimated that this sample is equivalent to 19.6% of the hunts originating from San Pablo de Shushufindi in one year.

[b]This column represents the estimated mean annual yield during the first two years following the establishment of San Pablo (for 23 hunters and an estimated 1441 individual one-day hunts per year).

[c]Since a tapir kill is a major village event, all of the tapir kills from September 1973 through March 1975 were recorded. The columns for Annual Kill and kcal Contribution have been adjusted so that the disproportionate reporting of tapir kills is taken into account.

Species Representation in Siona-Secoya Hunting Yields

Although the Siona-Secoya classify a large number of animal species as edible game, a comparatively small number of species are killed with frequency. Table 1 indicates the number of animals from significant species included in the 1973-75 hunting sample, as well as the projected mean annual kill during the first two years following the establishment of San Pablo, and the ranking of species by total caloric contribution to the Siona-Secoya diet. The white-lipped peccary (Tayassu pecari), collared peccary (T. tajacu), and woolly monkey (Lagothrix spp.) were by far the most significant game animals in terms of contribution to diet. The tapir (Tapirus americanus) and curassow (Mitu salvini) ranked fourth and fifth in terms of meat contribution, followed by a series of species whose contributions were relatively small.

Mean Weight of Hunting Yields

The 1973-75 sample of 283 one-day hunts produced a total yield of 6042.2 kg (13,317.0 lb) of butchered meat (i.e., gutted, but including bone). The mean yield per hunt, therefore, was 21.35 kg (47.1 lb) of butchered meat. The mean yield for the 148 hunt sample of June-August was 11.9 kg (26.2 lb) or 55.9% of the 1973-75 yield.

Are the Lower 1979 Yields a Consequence of Seasonal Factors?

Since the June-August 1979 yields fall at the end of the rainy season for this part of the Amazon Basin, it might be argued that

seasonal factors alone may account for the lower 1979 yields. For this reason it is useful to make a comparison with the yields for June-August 1974. In 81 hunts recorded for this period the mean yield was 41.4 kg (91.2 lb) of butchered weight per one-day hunt, and indicates that hunting can be very productive during these months. This very high yield, however, reflects the fact that seven tapir were killed during June-August, or 58% of the 12 tapir that were killed during the 18 months of fieldwork. If the tapir kills are omitted from both the 1974 and 1979 June-August yields, the mean butchered weight figures are 20.5 kg (45.2 lb) and 9.9 kg (21.8 lb) respectively.

This comparison indicates that the yields for the rainy season in 1974 were actually better than the mean yield for 18 months in 1973-75, and even when the tapir kills are omitted, the rainy season yields are nearly the same as the average yield for the 18-month period. It seems best, therefore, to interpret the lower June-August 1979 yields in terms of reduced game populations rather than in terms of seasonality. The 1973-75 observations indicate that the Siona-Secoya engage in hunting on a year-round basis, and that the major game animals are also taken year-round. For these reasons, I believe that it is acceptable to utilize the entire 1973-75 sample for comparison with the June-August 1979 sample, and interpret the data as indicating that hunting yields in 1979 are about 56% of what they were in 1973-75.

Distance and Time Factors

The Siona-Secoya utilize a variety of hunting grounds or zones in much the same manner as Hames (1979) has described in his locational analysis of Ye'kwana and Yąnomamö hunting. That is to say, these people recognize and identify a series of locations and biotopes which they exploit in their hunting, fishing, and collecting activities. Some of these areas are contiguous with settlements whereas others are as far as 60 km distant and can only be reached by journeys of several days in length. The Siona-Secoya also engage in morning or evening hunts and one-day hunts in addition to the longer "expedition" hunts of two or more days. The hunting data presented in this paper represent mean energy inputs and outputs for a sample which includes both short and long hunts within the various zones and biotopes.

It is evident that in 1979 Siona-Secoya hunters are having to travel farther to find game than in previous years. One indicator of this is that in one-day hunts in 1973-75 they used to travel southwest towards the Shushufindi River (5-10 km) to find game, whereas in 1979 they are crossing the river and travelling into the forests beyond it (individuals have stationed canoes at the river which they use in their crossings). Since it is impossible to accompany hunters on each hunt to estimate the distance covered, I use the time duration of the hunt as an indicator. (I estimate that the hunters cover 2-3 km per hour through the forest.) In 1973-75 the average time of an individual one-day hunt was 7.56 hours. In 1979 it is 8.48 hours,

so the length of the average day hunt has increased by 12%. In terms of distance travelled, the average one-day hunt in 1973-75 is estimated to have covered about 17 km, whereas in 1979 the estimate is about 20 km.

Hunting Efficiency

One method of evaluating hunting yields is to look at the caloric return of hunting by means of the following formula:

$$\text{Hunting Efficiency} = \frac{\text{kcal hunting yield}}{\text{kcal energy expended in hunting}}$$

The advantage of this formula over simple hunting yields is that it takes the factor of relative effort into account.

In order to calculate the caloric return of Siona-Secoya hunting, the mean yield in kilograms of butchered meat is reduced an additional 30% to allow for inedible bone and body parts, which gives the estimated edible portion. The mean caloric value of Siona-Secoya game is estimated to be approximately 170 kcal per 100 g of edible meat, or 1700 kcal per kg of edible meat (based on a survey of meats in Leung 1961).

Since most Siona-Secoya hunting time is spent walking over relatively level terrain, Montgomery's and Johnson's figure (1976) of six kcal/minute (or 360 kcal/hour) for the Machiguenga Indians of the Peruvian montana in this activity is taken as the basis for computing caloric expenditure.[2]

With these factors it is possible to estimate the 1973-75 and 1979 caloric returns in hunting with the following computations:

$$\text{1973-75 Hunting Efficiency} = \frac{1700 \text{ kcal } (21.35 \text{ kg} \times .7)}{360 \text{ kcal} \times 7.56 \text{ hr}} = 9.33$$

$$\text{1979 Hunting Efficiency} = \frac{1700 \text{ kcal } (11.9 \text{ kg} \times .7}{360 \text{ kcal} \times 8.5 \text{ hr}} = 4.65$$

These calculations indicate that the caloric return for hunting in 1979 is about 50% of what it was in 1973-75.

Overview of the Hunting Data

There is little new in the idea that the population of a prey species declines as predation increases (all other factors being constant). It follows, therefore, that the longer a hunting people stay at a specific site, the greater will be the depletion of local game populations. Even if we were not aware of the hunting conditions at San Pablo de Shushufindi, we could reasonably predict that hunting yields in the areas adjacent to the settlement would decline with time. As the data presented in this paper have shown, most of the indicators of hunting which have been used show trends in the anticipated direction:

1. The mean hunting yield has declined (from 21.3 to 11.9 kg)
2. The length of hunting trips has increased (from 7.56 to 8.48 hr/one-day hunt)
3. The caloric efficiency of hunting has declined (from 9.3:1 to 4.6:1)
4. Larger species appear to be more vulnerable predation than smaller species (see Table 2)
5. The percentage of trips in which no kill was made increased from 11.3% to 18.6%

In order to balance this information the following characteristics of Siona-Secoya hunting in 1979 must also be recognized:

1. The volume of game taken after six years of hunting continues to be considerable
2. A large majority (81.8%) of hunts are still "successful" (defined here as a hunt with at least one kill)
3. The rate of decline for some large species (e.g., collared peccary and howler monkey) is more gradual than might have been expected (see Table 2)
4. Hunting is still a very viable activity in terms of caloric return
5. Hunting continues to be the major source of dietary protein for the Siona-Secoya (about 60%)

Dietary Implications of the 1979 Hunting Yields

Dietary surveys conducted during the 1973-75 fieldwork indicated that the mean caloric intake for the Siona-Secoya was 2215 kcal/day, or almost precisely the 2223 kcal/day estimated mean requirement (for all age groups, following the FAO method of calorie requirement computation; cf. Vickers 1976: 131-133). With regard to protein consumption, the mean intake in 1973-75 was 65.3 g/day of animal protein and 15.4 g/day of vegetable protein, or a total of 80.7 g/day (for all age groups). The protein intake in 1973-75, therefore, was well in excess of recommended daily allowances. For example, the FAO recommended allowance for an adult male weighing 65 kg (143 lb) is 37-62 g/day of protein, whereas the mean intake for Siona-Secoya males weighing an average of 62.6 kg (138 lb) was 112.6 g/day.

The observed decline in Siona-Secoya hunting yields means that protein consumption is also down. It is estimated that the current mean protein intake for all Siona-Secoya age groups is about 41 g/day of animal protein and about 15 g/day of plant protein, for a total of approximately 56 g/day.[2] The indications are, therefore, that Siona-Secoya protein intake in 1979 is still better than adequate despite the decline in hunting yields.

For purposes of discussion, it may be useful to consider a "worst case" situation concerning protein intake in which the following hypothetical conditions prevail:

1. All animal protein is derived from hunting (neglecting fish as a source of protein)
2. Hunting yields continue to decline at the rate recorded from 1973-79 (this seems unlikely due to factors discussed in the following section of this paper)
3. Protein intake from vegetable sources is not increased

Under these worst case conditions, animal protein intake would drop to 17.6 g/day by 1985 and to 10 g/day by 1991. If vegetable protein intakes were held constant, the mixed daily intakes of protein would be about 33 g/day and 25 g/day, respectively. It is not certain that protein deficiency diseases would be manifested even at these hypothetically low levels, since recommended daily allowances are quite generous and human populations have been observed with far lower intakes without clinical signs of protein deficiency. As B. Abbott Seagraves writes in a recent analysis of nutritional stress:

> Criteria commonly accepted in identifying and measuring nutritional status, and the relationship between actual food intake and health, lack reliability and

> specificity....The standards for caloric and general nutrient requirements, such as those proposed by FAO and the U.S. National Research Council, have been increasingly discarded as a tool in the direct assessment of nutritional status, as they make no allowances for the possible environment-specific variations in human needs and adaptations....that a considerable range of nonpathological adjustment to calorie and protein intake is the rule rather than the exception is predicted by certain general characteristics of system structure and operation. For each of the many variables in a living system....there is a range of stability....all living systems possess remarkably effective means of responding to and mitigating stress and hence preventing serious strain (1977:196, 199-200).

Since the Siona-Secoya diet is composed of a large variety of foods from both wild and cultivated sources from a diversity of ecological zones, it appears that they have considerable capacity to compensate for shortages in any given food resource in a specific location at a specific time.

When Does the Game Run Out?

The data presented in this paper are the result of empirical field investigations and provide information on aggregate hunting yields through time at one indigenous settlement in the Amazon. The basic data are impartial and may be subject to varying interpretations by specialists. Proponents of the hypothesis that protein is the major limiting factor in Amazonian cultural dynamics may take the declining yields at San Pablo de Shushufindi as evidence which supports their position. Opponents of this view may prefer to emphasize that hunting at San Pablo de Shushufindi is still a very viable activity despite six years of heavy human predation on faunal resources.

In view of this debate, one might well ask, "When does the game run out?" or "When will the scarcity of game force the people to move?" Unfortunately, there is no simple answer to this question. The data presented in this paper indicate that yields at San Pablo have dropped by approximately 44% over a five- to six-year period. But this does not mean that five years is the half-life of all game species in a linear rate of decline. If this were so we could predict that in ten years the mean yield for Siona-Secoya one-day hunts would be 3.7 kg (8.2 lb) of butchered meat. But a hunting sample from a Siona-Secoya settlement on the Cuyabeno River reveals a mean yield of 5.67 kg (12.5 lb) butchered weight after more than 30 years of continuous habitation (Vickers 1975). So the data from Shushufindi and Cuyabeno suggest that the relationship between length of residence and hunting yields is an asymptotic one in which hunting yields start very high during the initial period of settlement, and then drop sharply for a period of several years after which the rate of decline slows. Figure 1 is a graph of the suggested relationship.

One reason for this relationship is the differential resistance of various species to hunting pressure. As Ross has pointed out (1978) smaller game such as the agouti and squirrel have a higher rate of reproduction due to short gestation periods and multiple births. Because of the availability of such species mean hunting yields are unlikely to decline to the zero point. Table 2 indicates a general tendency in which smaller species are becoming more frequent in hunting yields at San Pablo.

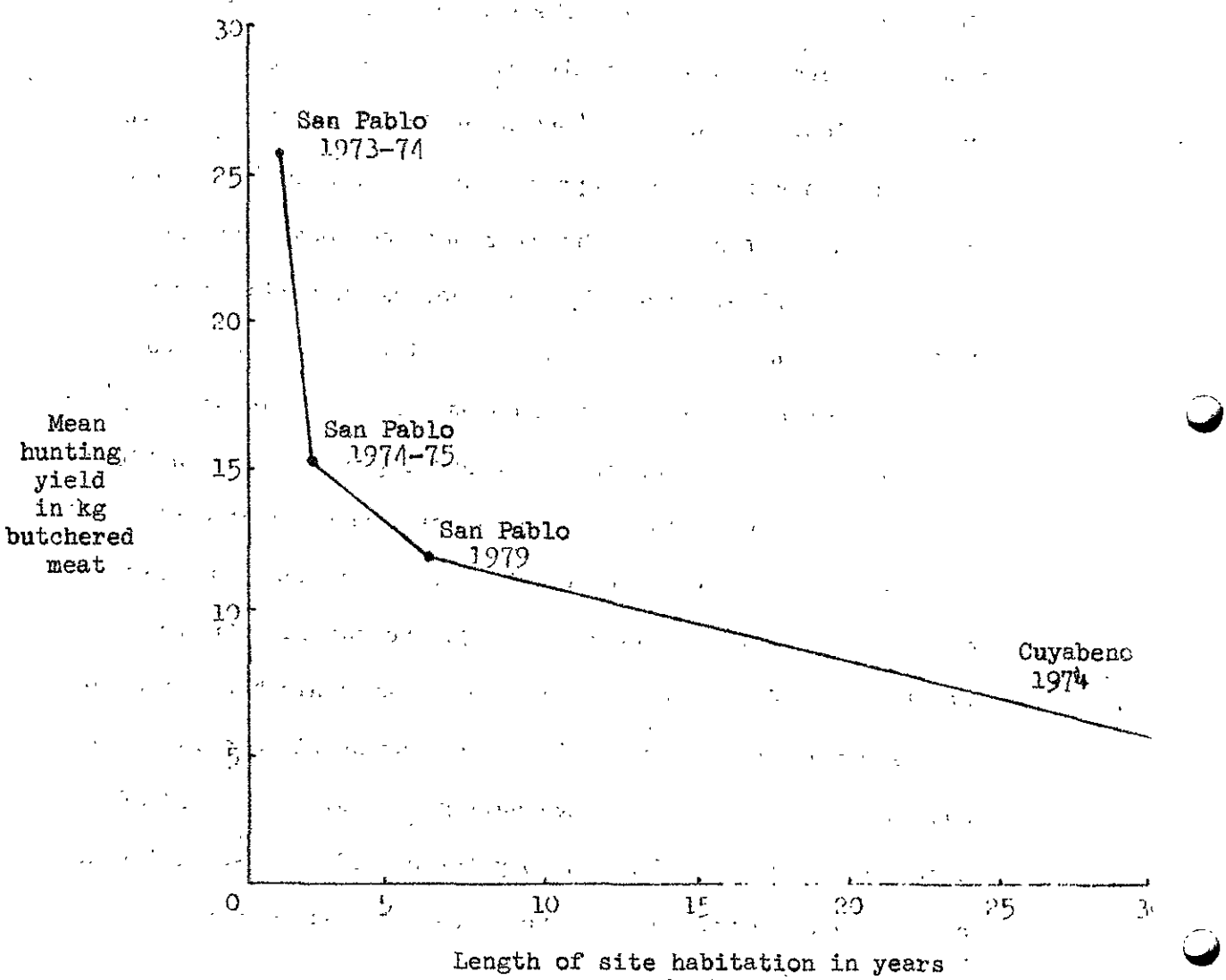

Figure 1. Hunting Yields as a Function of Length of Site Habitation.

Another significant fact is that most indigenous Amazonian settlements fission and/or relocate before game populations are totally decimated. Once again, the concept of hunting "efficiency" is useful; people become dissatisfied when yield relative to effort declines, and not just when yields reach zero. The fission and relocation process has already begun at San Pablo de Shushufindi as seven households have moved upriver towards the Eno River, and 10 of the remaining 15 households at San Pablo have made pioneer gardens downriver in anticipation of a future move. But hunting yields are not the only factor in this process; while it is true that the Indians are having to hunt farther from the settlement, and that their yields have declined, they are also complaining that each dry season they have to travel farther to make their gardens, that the palms they use to thatch their houses are scarce, that they have to carry their firewood over greater distances, that their neighbors cause them misery, and that San Pablo has become "boring" after six years of settlement. These emic perceptions reflect both obvious environmental realities and cultural themes which are nearly universal among the native peoples of the Amazon. It is my view that these statements concerning flora and fauna, interpersonal relations, and attitudes are related components of a cultural-ecological system which has remained viable for at least several thousand years because of cultural practices which limit population growth and promote dispersal and movement (e.g., abortion, infanticide, ritual restrictions on sexual

TABLE 7. COMPARISON OF SPECIES KILL PROBABILITIES AT SAN FABIO DURING FIRST TWO YEARS OF SETTLEMENT AND AFTER SIX YEARS

Species	Per Cent Chance of Kill During One Day H		
	1973-75[a]	June-August 1974[b]	June-August 1979[c]
Primary targets			
Tapir (Tapirus americanus)	4.3	8.6	2.0
White-lipped peccary (Tayassu pecari)	33.1	28.4	17.6
Collared peccary (T. tajacu)	30.6	16.0	21.6
Woolly monkey (Lagothrix spp.)	46.8	40.7	23.6
Howler monkey (Alouatta seniculus)	4.0	3.7	3.4
Curassow (Mitu salvini)	21.9	14.8	15.5
Piping guan (Pipile pipile)	11.4	4.9	6.1
Spix's guan (Penelope jacquacu)	5.0	6.2	2.7
Trumpeter (Psophia crepitans)	5.8	6.8	0.7
Secondary targets			
Agouti (Dasyprocta sp.)	3.6	4.9	4.7
Paca (Cuniculus paca)	4.0	0.0	0.7
Squirrel (Sciurus sp.)	0.4	0.0	2.7
Armadillo (Dasypus spp.)	2.2	0.0	2.7
Caymen (Caiman spp.)	0.7	0.0	1.4
Tortoise (Geochelone sp. or Testudo sp.)	1.1	1.2	0.7
Toucan (Pteroglossus sp. and Ramphastos sp.)	1.1	1.2	2.0

[a]Based on a sample of 283 individual one-day hunts.

[b]Based on a sample of 81 individual one-day hunts.

[c]Based on a sample of 148 individual one-day hunts.

activity, warfare and witchcraft), thereby allowing for resource renewal following periods of depletion. That is to say, these cultural practices represent an adaptation to a variety of Amazonian environmental resources at a given level of technology (shifting horticulture, hunting, collecting and fishing).

Conclusion

This paper has focused on one resource--hunted game--and has indicated the rate of game depletion at one settlement over a six-year period. The time depth of the sample data provides useful insights into predator-prey relationships between humans and animals in the Amazon. Additional studies on the utilization of other resources are needed, however, before definitive quantitative statements can be made on the relative significance of specific environmental factors as "limiting factors" in Amazonian cultural development. My own position is that the availability of protein resources may be a limiting factor on community size, stability, and political organization in specific locations at specific times, but that other ecological factors such as soil fertility, drainage, floral resources, level of technology, and the presence of other human populations may also play the role of a limiting factor at specific locations and times. It is also likely that there are even more cases where factor interaction is present. San Pablo is a good example of this, for the depletion of flora, fauna, and nearby

arable land are all contributing to the incipient fissioning of the settlement. These data suggest that a systemic (i.e., multi-factorial) model of tropical forest cultural adaptation is likely to prove more useful than any single limiting factor hypothesis.

NOTES

[1] The 1973-75 research was supported by fellowships from the Henry L. and Grace Doherty Foundation and the National Institute of Mental Health (1Fol MH 58552-01). The 1979 fieldwork was made possible by a grant from the Florida International University Foundation, Inc. The Ecuadorian affiliation for the research was through the Instituto Nacional de Antropologia e Historia under the directorship of Arq. Hernan Crespo Toral. In previous publications (Vickers 1975, 1976, 1979) San Pablo de Shushufindi was referred to as simply "Shushufindi"; the designation "San Pablo" was suggested by a Secoya bilingual teacher in 1974 and has now gained wide acceptance in the study region. I would like to thank Raymond B. Hames, Department of Anthropology, Pennsylvania State University, for reading and commenting on the initial draft of this paper.

[2] The mean animal protein intake estimate of 41 g/day/individual includes 32 g/day from hunted game and 9 g/day from fish.

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