In this article I examine the use of insects as food by Tukanoan Indians in the Northwest Amazon and discuss both the characteristics of the species exploited and their significance in the diet. Data on insect collection were obtained from harvest records and participant-observation. Dietary intake was determined from weighed food intake records. The insects collected belonged to over 20 species. The most important in the diet were those which formed large, highly predictable aggregations: beetle larvae (genus Rhynchophorus), ants (genus Atta), termites (genus Syntermites), and caterpillars (families Noctuidae and Saturniidae). The composition of insects is similar to that of other animal foods. Their inclusion in the diet was frequent and inversely related to the consumption of fish and game. They provided up to 12% of the crude protein derived from animal foods in men's diets and 26% in women's diets during one season of the year.

MUCH OF THE RECENT INTEREST IN HUMAN ECOLOGY IN AMAZONIA has centered around questions related to the amount of protein available in wild fauna on a sustained yield basis (Harris 1974; Gross 1975; Ross 1978; Chagnon and Hames 1979; Milton 1984). For the most part, wild fauna has been equated with large vertebrates. Although Beckerman (1979) pointed out that other sources of dietary protein, such as wild plants and invertebrates, need to be considered as well, the acquisition of these resources is less dramatic and has received little attention. With regard to insects this is perhaps surprising because they are a very conspicuous group and account for a large proportion of the forest's animal biomass (Fittkau and Klinge 1973:6-7). Furthermore, their use as food is very widespread and has been mentioned by a number of investigators. In his comprehensive review of the early literature, Bodenheimer (1951) cites more than 20 references. More recent work on the Yukpa (Ruddle 1973), Yanamamo (Smole 1976), Yanomami (Lizot 1977), Ache (Hurtado et al. 1985), and the Maku (Milton 1984) indicate that insect fauna continue to be included in indigenous diets.

The literature referring to the use of insects as food contains lists of edible species but little discussion of the characteristics of insects that are relevant to their selection as food resources in a tropical forest environment. Furthermore, although the suggestion that insects are an important component of indigenous diets is common (Bodenheimer 1951:11, 19; Ruddle 1973:14; Milton 1984:14), there have been no attempts to evaluate their dietary significance in terms of the frequency with which they are included in the diet, the quantities eaten, or their contribution to energy and protein intake. Lizot's (1977) work is an exception in that he estimated the percent contribution by weight of insects to Yanomami diet. His data indicate that women at Kakashiwè consumed nothing but insects during a 28-day period (1977:509).

My interest in the use of insects as food stems from fieldwork among Tatuuo-speaking Tukanoan Indians in the Northwest Amazon, and my observation that insect fauna was frequently included in the diet, sometimes in relatively large amounts. My purpose in this article is first, to define the characteristics of the insect species consumed, especially...
in terms of their predictability as food resources in the environment, and second, to evaluate the dietary significance of entomophagy for this population. A larger goal is to provide observations and data of relevance to the question of protein availability in Amazonia. The research presented here indicates that insect fauna is frequently consumed and clearly an important food resource for Tukanoans. I thus suggest that a consideration of the role of insect fauna in the diet needs to be included in any evaluation of the adequacy of protein resources in Amazonia.

Study Area

The observations reported here are based on fieldwork in the Colombian Vaupés region, primarily in the village of Yapú on the upper Papurí River between November 1976 and April 1978. The population density of the area is low, about 0.2 persons per square kilometer. The upper Papurí is a black water river draining an area of low, humid tropical rain forest broken with patches of caatinga, a low forest vegetation on sandy soils. Mean annual temperature is about 26°C and rainfall about 3,500 mm per year. Seasonal differences in rainfall are not well marked, but there is a long dry season of slightly less rainfall from November to February, and a short one in August. The principal rainy season begins in March, and July is usually the month of maximum rainfall. There is a second shorter rainy season from September through October.

At the time of the study, Yapú was a relatively large village settlement of over 100 persons. It was and still is considered a Tatuyo village, because the core members of the village, politically and socially, are Tatuyo, and the village is located on a site that has been occupied by Tatuyo since early in the century. The Tatuyo are one of the various linguistically defined exogamous groups of Tukanoan Indians in the Northwest Amazon (see Jackson 1983). I refer to the residents of Yapú as Tatuyo although members of several other groups of Tukanoans reside in the village as well.

Like other Tukanoans, the Tatuyo at Yapú are slash and burn horticulturalists. Cassava was and is the principal crop and dietary staple. During the period of field study it was supplemented with a variety of cultivated and wild vegetable foods, fish, game, and invertebrates. Neither domesticated animals nor tinned food were used. The diet has been described (Dufour 1983, 1984), and at least for adults, appears to be adequate in energy and protein.

Methods

As part of a study of village energy flow, samples of insect material included in the diet were collected and preserved by drying (adult Coleoptera), or in 70% isopropyl alcohol (all other specimens). Almost all of the specimens were collected in the vicinity of Yapú on the Río Papurí (about 0° 31” North and 70° 32” West). The wasp specimens identified as Apoica thoracica Buysson were collected on the Caño Yi, and ants identified as Atta laevigata were collected at Acaricuara. Both the Caño Yi and Acaricuara sites are within 50 km of Yapú, and both species were collected for consumption while traveling with residents of Yapú. Caterpillars of the family Lacosomidae were collected at Querarimiri on the Río Cuduyari (within 80 km of Yapú) and they were reported to also occur upstream of Yapú. There are no significant differences in altitude or terrain within the region. Identifications were provided by the Insect Identification and Beneficial Insect Introduction Institute, United States Department of Agriculture (see Acknowledgments).

The proximate composition of four commonly eaten insect species was determined for representative samples preserved by traditional techniques of dry-toasting (Hymenoptera) and smoke-drying (Coleoptera larvae). The quantities of insects collected were obtained by routinely weighing all foods brought into the village for consumption. Dietary intake of insect material was ascertained using the weighed intake procedure. An observer accompanied each subject for a 24- to 72-hour period and weighed all food items prior to consumption on a 500-g dietary
scale accurate to 1 g. On the occasions when it was impossible to accurately weigh food before it was consumed, weight was estimated on the basis of a duplicate portion. The protein values for animal foods were taken from the results of the proximate analyses and published food composition tables.

Weighed food intake records were kept during November through January, and May through June. In the November-January period food intakes were recorded for 72 hours for 8 men and 9 women, a total of 24 man-days and 27 woman-days. In the May-June period food intakes were recorded for 24 hours for 10 men and 13 women. November is the beginning of the long dry season and January generally the driest month of the year. May-June is the latter part of the long rainy season. The subjects were adult men and women between the ages of 18 and 55 years, all of whom appeared to be in good health, were engaged in normal activities, and were not adhering to any culturally defined food restrictions at the time.

Results

Diversity of Insects Collected

The edible insects used at Yapú are listed in Table 1. These insects belong to 4 orders and include over 20 species. They are considered by order and family as this grouping defines shared characteristics of relevance to their use as food resources.

Coleoptera. A number of adult beetles, weevils, and their larvae were collected, but the most important of these were larvae of weevils, genus *Rhynchophorus*. These larvae are commonly referred to as "palm grubs" since they are found in the pith of felled palms. The Tatuyo felled palms to harvest the fruits, and often returned at a later date to harvest the larvae which subsequently developed in the pith. Palms were also cut specifically with the expectation that they would be invaded by weevils and the larvae ready to harvest in two to three months. Thus, the larvae were both a by-product of the harvesting of palm fruits and "cultivated." In the latter sense they were frequently used as a food cache by men on hunting and fishing trips away from the village.

Of the other beetles and beetle larva collected, all were woodboring and most commonly collected from under the bark of decaying logs found in gardens, their presence detected by the sawdust tailings resulting from their woodboring activity. The larvae of these beetles were preferred over the adults, although the latter were occasionally eaten as well.

Hymenoptera. The order Hymenoptera includes ants, wasps, and bees. Ants and wasp brood were collected, but only Attine ants of the genus *Atta* were collected in quantity. *Atta* are leaf-cutting ants, conspicuous on the forest floor as they carry freshly cut leaf fragments to their subterranean nests. The genus includes two unusually large forms, the winged reproductives, or alates, and a worker with a disproportionally large head referred to as a "soldier."

Both soldiers and female alates were collected for food. Soldiers were gathered by inserting a probe, such as a palm leaf rib stripped of leaves, into a suitable nest entrance and removing those soldiers attaching themselves to it. The female alates were collected as they left the nest by the thousands in colonizing, or nuptial flights. These females, their abdomens engorged with a fatty egg mass, are very large ants and were a highly prized delicacy. The colonizing flights occurred in the early part of the principal rainy season and seemed to be triggered by a particular pattern of precipitation in which a day of very heavy rain was followed by a day of lighter rain. There was sometimes an additional flight from the nest at the beginning of the second, shorter rainy season. It was possible to predict the day of the flight very accurately from the weather pattern and type of activity at the nest, and the time of the flight was a recognized species specific characteristic (see Table 1). The female alates of *A. cephalotes* were particularly easy to collect since they left the nest just before dawn and could be attracted to a burning flare and caught neatly in
Table 1
Summary of the characteristics of insects used as food in the northwest Amazon.

<table>
<thead>
<tr>
<th>Species</th>
<th>Tatuyo name</th>
<th>Stage eaten</th>
<th>Length(^b) (cm)</th>
<th>Weight(^b) (g/ind.)</th>
<th>Spatial(^c) dist.</th>
<th>Acq. rate(^d) (g/h)</th>
<th>Temporal availability(^e)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coleoptera</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buprestidae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Euchroma gigantea</em> (L.)</td>
<td><em>boopika</em></td>
<td>larva</td>
<td>?</td>
<td>?</td>
<td>++</td>
<td>?</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adult</td>
<td>6.5</td>
<td>3.0(^d)</td>
<td>+</td>
<td>?</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Cerambycidae</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Acrocinus longimanus</em> (L.)</td>
<td><em>pikoroa</em></td>
<td>larva</td>
<td>9.0</td>
<td>7.7(^w)</td>
<td>++</td>
<td>250</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Curculionidae</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Rhynchophorus spp.</em></td>
<td><em>waraa</em></td>
<td>larva</td>
<td>5.5</td>
<td>3-16</td>
<td>++</td>
<td>2,000</td>
<td>NS, 2-3 mos. after felling palm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adult</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>?</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Passalidae</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Genus ?</em></td>
<td><em>yayaru</em></td>
<td>larva</td>
<td>4.5</td>
<td>1.5(^w)</td>
<td>++</td>
<td>25</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adult</td>
<td>4.0</td>
<td>1.9(^w)</td>
<td>++</td>
<td>25</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Scarabaeidae</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td><em>Megaceras crassum</em> Prell</td>
<td></td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>adult</td>
<td>7.0</td>
<td>2.2(^d)</td>
<td>+</td>
<td>?</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Hymenoptera</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formicidae(^e)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><em>Atta cephalotes</em> (L.)</td>
<td><em>mekaiyaa</em></td>
<td>soldier</td>
<td>1.0</td>
<td>0.1(^w)</td>
<td>++</td>
<td>200</td>
<td>NS, &gt; 1 harvest/nest</td>
</tr>
<tr>
<td></td>
<td><em>mekaiyaa liara</em></td>
<td>alate ?</td>
<td>2.0</td>
<td>0.8(^w)</td>
<td>++</td>
<td>3200</td>
<td>early-mid RS, 1 flight/nest, 0430 h.</td>
</tr>
<tr>
<td><em>Atta laevigata</em> (F. Smith)</td>
<td><em>ruhaa</em></td>
<td>soldier</td>
<td>1.0</td>
<td>0.1(^w)</td>
<td>++</td>
<td>200</td>
<td>NS, &gt; 1 harvest/nest</td>
</tr>
<tr>
<td></td>
<td><em>ruhaa liara</em></td>
<td>alate ?</td>
<td>2.5</td>
<td>0.8(^w)</td>
<td>++</td>
<td>200</td>
<td>early-mid RS, 1 flight/nest, 1500 h.</td>
</tr>
<tr>
<td><em>Atta sexdens</em> (L.)(^g)</td>
<td><em>biapuna</em></td>
<td>soldier</td>
<td>1.0</td>
<td>0.1(^w)</td>
<td>++</td>
<td>200</td>
<td>NS, &gt; 1 harvest/nest</td>
</tr>
<tr>
<td></td>
<td><em>biapuna liara</em></td>
<td>alate ?</td>
<td>2.5</td>
<td>0.6</td>
<td>++</td>
<td>200</td>
<td>early-mid RS, 1 flight/nest, 1600 h.</td>
</tr>
<tr>
<td><strong>Vespidae</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Apoica thoracica</em> Buysson</td>
<td><em>utia</em></td>
<td>pupa</td>
<td>2.5</td>
<td>0.2(^w)</td>
<td>++</td>
<td>?</td>
<td>NS, 1 harvest/nest</td>
</tr>
<tr>
<td><em>Polybia rejecta</em> (F.)</td>
<td><em>utia</em></td>
<td>pupa</td>
<td>?</td>
<td>0.2(^w)</td>
<td>++</td>
<td>?</td>
<td>NS, 1 harvest/nest</td>
</tr>
<tr>
<td><em>Stelopolybia angulata</em> (F.)</td>
<td><em>totti utia</em></td>
<td>pupa</td>
<td>20</td>
<td>0.2(^w)</td>
<td>++</td>
<td>?</td>
<td>NS, 1 harvest/nest</td>
</tr>
<tr>
<td><strong>Isoptera</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Termitidae; Nasutitermitinae</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><em>Syntermes parallelus</em> Silvestri</td>
<td><em>bupena</em></td>
<td>soldier</td>
<td>1.5</td>
<td>0.2(^w)</td>
<td>++</td>
<td>200</td>
<td>NS, &gt; 1 harvest/nest</td>
</tr>
<tr>
<td>Genus</td>
<td>Species</td>
<td>Development Stage</td>
<td>Sample Size</td>
<td>Availability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------------</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Syntermes synderi Emerson a</td>
<td>meka bupuara</td>
<td>alate ♀</td>
<td>2,000</td>
<td>early-mid RS, 1 harvest/nest, late afternoon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>soldier</td>
<td>200</td>
<td>NS, &gt; 1 harvest/nest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macrotermes sp.</td>
<td></td>
<td>alate ♀</td>
<td>2,000</td>
<td>early-mid RS, 1 harvest/nest, late afternoon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>soldier</td>
<td>200</td>
<td>NS, &gt; 1 harvest/nest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lepidoptera</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hesperiidae</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Genus ?</td>
<td>kiinamono</td>
<td>larva</td>
<td>&lt; 10</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lacosomidae</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Genus ?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noctuidae</td>
<td>batia</td>
<td>larva</td>
<td>?</td>
<td>long RS during 1–2 weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genus ?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notodontidae</td>
<td>menheia</td>
<td>larva</td>
<td>?</td>
<td>short DS—begin short RS during 1–2 weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genus ?</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturniidae</td>
<td>hutia</td>
<td>larva</td>
<td>?</td>
<td>begin short RS during 1–2 weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A number of other insects were observed being consumed but not formally identified. These included two varieties of termites (meka bupuara jabara and butuwa), a grub (compiapu), and a lemon-flavored ant (bocorua).

*Length and weight data are average values of representative samples. Weight of specimens preserved in alcohol (w), weight of dried specimens (d), all other weights are for live insects.

*Spatial distribution defined as highly clumped with 50 or more individuals in close proximity in a single nest or within a single log (+ + +), somewhat clumped with 3–10 individuals in close proximity (+ +), or dispersed with individuals encountered singly (+).

*Acquisition rate is the maximum rate observed per attempt per person for a limited number of observations. Figures are rounded and do not include travel time to site. Search time is included in the acquisition rate for woodboring beetle larvae other than Rhynchophorus, but not for other insects. Acquisition time for alate ants and termites was defined by duration of swarming, which was somewhat less than one hour.

*Temporal availability is defined as nonseasonal (NS), i.e., available throughout the year, during the rainy season (RS) or dry season (DS). Time of the day is indicated where relevant.

 Larvae were collected from a variety of palms but Mauritia flexuosa and Jessenia sp. seemed to be the most important. Small and large forms of the larvae were often collected from the same palm and either represent different species or different instars of the same species. Adults were rarely used as a source of food. They are heavily sclerotized and have a very small edible portion.

Two of the samples identified as A. sexdens were from colonizing flights that occurred between 1300 and 1400 hours. Assuming that differences in the timing of colonizing flights result in reproductive isolation, these samples may represent a subspecies of A. sexdens. The Tatuyo distinguish them by name, color, and taste.

Tentative identification.
a basket. Those of the other species of *Atta* had colonizing flights during the day, and were collected by handpicking them as they emerged from holes spread over the nest surface.

Nests of several species of wasps were also collected, and the brood eaten. The species identified were all tree-dwelling social wasps. The nests of these wasps were quite large, but usually high in the trees and therefore hidden in the foliage.

**Isoptera.** Several species of termites were collected, but leaf-cutters of the genus *Syntermes* were the most important in the diet. The soldiers of *Syntermes* are about the same size and were collected in the same manner as the soldier ants. The female alates of *Syntermes* are smaller than alate ants of the genus *Atta*, and were collected for fishing bait as well as food. Acquisition rates were as high as those for *Atta* when leaf traps were used to channel the alates into a restricted number of exit holes.

**Lepidoptera.** Two species of colonial caterpillars were collected in particularly large quantities. The first, *hutia*, was a lightly haired, smallish caterpillar that nested in secondary growth and was as important for fishing bait as food. The second species, *batiya*, was a larger, brightly colored caterpillar that nested in a common primary forest tree, *Erisma Yapura*, and was collected as it descended from the canopy to pupate on the forest floor. Both species were available in only a limited portion of the range covered by their plant hosts. This patchy distribution was especially striking in the case of *batiya*. Although the host tree was very common in the area of the village, the caterpillars only appeared in a region several hours’ walk to the northeast.

Two varieties of caterpillars using cultivated plants as hosts were also collected. One was found on cassava leaves, but only occasionally encountered, and the other used a cultivated tree (*Inga* sp.) as a host, but neither the tree nor the caterpillar were very common in the Yapú area. Several other varieties of edible caterpillars were named by informants, but none of these were observed being used.

**Sex of the Collector**

Adult men collected insect species which required felling trees (wasp brood), and splitting open felled logs (*Rynchophorus* larvae). Men, women, and older children collected *Lepidoptera* and *Coleoptera* larvae (other than *Rynchophorus*), and the alates of *Atta* and *Syntermes*. Women were responsible for collecting all of the ant and termite soldiers. Because this kind of collecting occurred throughout the year and was relatively time consuming, women probably devoted more time to insect collection than did men or children.

**Contribution of Insects to Diet**

**Quantities of Insects Collected.** Figure 1 shows the quantities of insects brought back to the village during a six-month period from April through June, and August through October. The *Coleoptera* were almost exclusively larvae of the genus *Rynchophorus*. The quantities recorded averaged less than a kilogram per month for April, May, and June and less than 100 grams per month in August, September, and October. *Coleoptera* larvae seemed to be harvested throughout the year, but most were consumed away from the village by men on hunting-fishing trips, and by women in the course of gardening or other work.

Ants and termites were collected throughout the year, but collection rates showed two peaks of about 16 and 10 kg per month, respectively. The first peak was in April-May, early in the principal rainy season, when most of the nuptial flights occurred. Appreciable quantities of *Syntermes* soldiers were also collected in May because men and adolescent male initiates were adhering to ritually restricted diets in which ant and termite soldiers were the only animal food permitted. The second smaller peak in September corresponded again to nuptial flights.

The collection of caterpillars was limited to August and September, but the quantities were impressive: 26 kg of *hutia* in August and 39 kg of *batiya* in September. The value of
INSECTS AS FOOD

Quantities of insects harvested at Yapi during two periods, April through June and August through October. Number of individuals resident in the village averaged about 108 during both periods.

39 kg is the estimated fresh weight of the caterpillars calculated from the weight of smoke-dried batyia brought back to the village by five household groups, and an unknown proportion of what was actually harvested.

Food Value of Insects. The composition of some of the insects collected is compared to other animal foods in Table 2. The moisture content of all samples was low, and for the sake of comparison can be considered similar. The values for river fish are the average values for two commonly used varieties, smoke-dried and ground into a powder. Since this mode of preparation includes bone and scale material, the protein value is lower than that of fileted fish.

The energy value of the insects shown is high, between 425 and 661 kcal per 100 g. The energy values for female alate ants (Atta sp.) and Rhynchophorus larvae are the highest, as both of these are rich in fat. The crude protein values for all insects are relatively high as well. The values for ants, termites, and caterpillars are higher than those for dried fish. In terms of less exotic foods the proximate composition of the ants, palm grubs, and caterpillars is comparable to that of goose liver, pork sausage, and beef liver, respectively. The composition of termite soldiers is roughly comparable to that of non-oily fish, although the latter are higher in protein.

Patterns of Insect Consumption. The frequency of insect consumption shown by the food intake records for November-January and May-June is compared to that of fish and game in Table 3. Fish was by far the most frequently consumed animal food, appearing in 88% of the diet records of males and 78% of those of females. Insects were the second, appearing in 26% of the diet records of males and 32% of those of females. Males consumed fish somewhat more frequently, and insects somewhat less frequently than did women,
Table 2  
Nutritional value of commonly consumed insects compared with other animal foods (Composition per 100 g edible portion).

<table>
<thead>
<tr>
<th>Food</th>
<th>Moisture (%)</th>
<th>Energy (g)</th>
<th>Protein (g)</th>
<th>Fat (g)</th>
<th>Ash (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ants, female sexuals* (Atta sexdens)</td>
<td>6.1</td>
<td>628</td>
<td>39.7</td>
<td>34.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Ants, female sexuals* (Atta cephalotes)</td>
<td>6.9</td>
<td>580</td>
<td>48.1</td>
<td>25.8</td>
<td>2.3</td>
</tr>
<tr>
<td>Termites, soldiers* (Syntermes sp.)</td>
<td>10.3</td>
<td>467</td>
<td>58.9</td>
<td>4.9</td>
<td>4.8</td>
</tr>
<tr>
<td>Palm grubs, smoke dried* (Rhyncophorus sp.)</td>
<td>13.7</td>
<td>661</td>
<td>24.3</td>
<td>55.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Caterpillars, smoke dried* (various species)</td>
<td>11.6</td>
<td>425</td>
<td>52.6</td>
<td>15.4</td>
<td>4.6</td>
</tr>
<tr>
<td>River fish, smoke dried**</td>
<td>10.5</td>
<td>312</td>
<td>43.4</td>
<td>7.0</td>
<td>20.3</td>
</tr>
<tr>
<td>Tapir, smoke dried*</td>
<td>10.3</td>
<td>516</td>
<td>75.4</td>
<td>11.9</td>
<td>3.5</td>
</tr>
</tbody>
</table>

*Proximate analyses were provided by the Instituto Agropecario de Colombia in Bogotá. Samples were prepared by dry-toasting in the field. Values are for single determinations.

**Proximate analyses were provided by the Instituto Colombiano de Bienestar Familiar, Bogotá, Colombia. Values are for single determinations.

*The values for caterpillars are from Wu Lueng, Busson, and Jardín (1968:167).

Table 3  
Types of animal foods consumed by Yapú men and women on days surveyed.

<table>
<thead>
<tr>
<th>Animal food</th>
<th>Man-days</th>
<th>Women-days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Fish only</td>
<td>17</td>
<td>50</td>
</tr>
<tr>
<td>Fish and insects</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td>Fish and game</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Fish, game, and insects</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Game and insects</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Game only</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Insects only</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No animal food</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>100</td>
</tr>
</tbody>
</table>

but these differences are not statistically significant (chi-square = 0.81, df = 1). However, insects were the only source of animal food in women’s diets on 5 of the 40 days (12%) for which diet records were kept and were never the sole source in men’s diets. These differences are significant.

The contributions of fish, game, and insects to the animal protein component of the diet are shown in Table 4. Most of the animal protein in the diet was from fish. Insects provided about 4% of the animal protein in men’s diets in the November-January period, and 2% in women’s. Most of the insect protein in the men’s diet was from palm grubs,
and in the women’s diet from both grubs and termites. Insects were more important in the May-June period, providing 12% of the animal protein in men’s diets and 26% in women’s. In both men’s and women’s diets most of the insect protein was from ants and termites. Animal foods provided almost 75% of the total protein in the diet in the November-January period. In May-June they provided somewhat less, about 70% of the total protein in men’s diets and about 60% in women’s.

Insects also contributed fat to the diet. In the November-January period the fat obtained from insects accounted for 23% and 7% of the fat provided by animal foods for men and women respectively. The corresponding figures for May-June were 18% and 20%.

**Discussion**

*Characteristics of Insect Species Included in the Diet*

The species most often used for food exhibited highly clumped distributions during the part of their life cycle that was harvested. Hymenoptera (ants and wasps) and Isoptera (termites) are social insects, and therefore aggregated throughout their life cycle. Ants of the genus *Atta* form some of the largest ant colonies known (Weber 1972:1). For Coleoptera and Lepidoptera, the larval stage is, after the egg, the stage of the life cycle at which the organisms are the most numerous, and highly aggregated. The adults are more mobile and widely dispersed. Furthermore, the larval stage is often long in proportion to that of the adult (Daly 1985:426) and therefore offers a greater harvesting opportunity.

In general, the stage of the life cycle collected was the largest form and that which had the highest energy value for human consumers. For Coleoptera and Lepidoptera this is the larval stage. Larvae are devoted to feeding and exhibit a progressive increase in weight with each stage of development or instar (Chapman 1969:388). In comparison to the last instar, adult forms have a lower body mass and a hardened exoskeleton, which reduces their digestibility. In Vespidae (wasps) the pupal forms are similar to the adults in size, but soft-bodied and hence should be more digestible. In the case of Formicidae (ants), the female alates, with their egg mass and energy reserves in the form of fat (Weber 1972:35), have the highest energy content of any form. Of the nonreproductive forms the soldiers are the largest and have the highest edible portion. The same generalizations should be true of the termite alates and soldiers.

The insect forms collected in the largest quantities were the most predictable resources in space and time. Ants of the genus *Atta* and termites of the genus *Syntermites* inhabited nests that were irregularly distributed in the environment, but easily recognized, and the
location of conveniently located nests was known. The colonies are long lived and the soldiers could be harvested repeatedly throughout the year. Alates, however, could only be collected at the time of their nuptial flights. Although of short duration, the timing of flights from particular nests was highly predictable, if both weather conditions and activity at the nest could be monitored. The latter was crucial to a successful collecting attempt, and only realistic for nest sites close to the village or near resource areas such as gardens. Attempts to predict the day of nuptial flights for nests at a distance from the village on the basis of weather patterns alone were usually unsuccessful.

Pupation of caterpillars of the families Noctuidae and Saturniidae occurred at known times of the year, on particular host plants in particular areas of forest. Although collection time was measured in days rather than hours, their temporal availability was limited, and the species collected were those occurring in areas of forest that were readily monitored. One species of caterpillar (family Lacosomidae; "outunima" in Cubeo) collected in large quantities on the Rio Cuduyari occurred upstream of Yapú but was not collected during the field study, reportedly because of the uncertainty in the timing of its appearance. The patchy distribution of caterpillars is probably what makes them an important item of ceremonial exchange among Tukanoans (see Hugh-Jones 1979).

Of the Coleoptera, the distinction between those harvested in larger as opposed to smaller quantities is not as clearly defined by differences in predictability. *Rhynchophorus* larvae were essentially a managed resource, found with great regularity in the pith of felled palms. Other varieties of woodboring beetles and their larvae were also found with regularity at garden sites, but generally in smaller numbers, usually less than 20 individuals.

The other insects collected, the brood of social wasps, Hesperiidae and Notodontid caterpillars, and two unidentified types of larvae, were less predictable in occurrence. Wasp nests appeared to be randomly distributed in the environment, were relatively difficult to locate, and destroyed in the harvesting process. The caterpillars appeared during recognized seasons and on known host plants, but in very small numbers. The occurrence of the two unidentified types of larvae was not easily predictable. Each appeared in the village on only one occasion, and informants claimed they were unable to locate other samples.

The insect forms collected were all relatively large insects. Soldiers and sexuals are the largest forms of *Atta* and some of the largest ants known. The soldiers and winged reproductive of *Syntermes* are the largest forms of the genus, with the exception of the queen, and fairly large insects (Araujo 1970:566). In general, beetles are considered large to medium insects. *Rhynchophorus* are among the largest of all herbivorous beetles (Crowson 1981:585), and those of the families Buprestidae, Cerambycidae, and Scarabaeidae are also large beetles (Crowson 1981:8).

Informants could name more edible insect species than were actually observed and collected during the field study. They can, for example, readily name at least 8 varieties of edible wasps, and more than 10 varieties of edible ants. There are several factors that may account for the discrepancy in number between the observed and enumerated varieties. First, the data on insect collection derived from harvest records included only the material brought back to the village and therefore underrecorded the use of insects which were typically consumed as they were collected. This was usually the case with the larvae of woodboring beetles. Furthermore, it is assumed that some of the insect material actually brought back to the village went unnoticed because it came in small packages at odd times of the day, or was effectively hidden. The latter sometimes occurred with prized foods, especially small quantities of *Rhynchophorus* larvae. The diet records provided a very accurate account of insect use, but for only a limited number of days.

Second, the period of observation may have been inadequate to record all varieties of insects that are harvested opportunistically, such as wasps, or only collected under certain social circumstances. An example of the latter was the unidentified lemon-flavored ant that was collected for use as a condiment when salt was tabooed. Third, not all va-
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Varieties recognized as edible were found within the usual resource area exploited for insect fauna. Foraging for insects was usually restricted to an area within about 15 minutes’ walk from the village, and in and around gardens. This was a smaller area than that exploited for fish and game resources, but essentially the same area in which most of the wild vegetable foods were collected. The only exceptions were the Noctuid caterpillars which were collected within the traditional territory of a neighboring village and in cooperation with that group, and the Rhynchophorus larvae “cached” near hunting/fishing camps.

Varieties of Insects Used by Other Native Amazonians

The forms of insects consumed by Tukanoans largely coincide with those reported for other traditional populations in Amazonia. The use of caterpillars and beetle larvae, especially “palm grubs,” appears to be widespread and has been reported by a number of observers (Bodenheimer 1951:308; Denevan 1971:511; Lizot 1977:509; Ruddle 1973:95; Beckerman 1977:153; Milton 1984:14; Hurtado et al. 1985:17). The use of adult beetles seems to be less common, but has been reported for the Yukpa (Ruddle 1973:95) and Ache (Hurtado et al. 1985:17). The consumption of alate ants occurs in all of Amazonia (Bodenheimer 1951:305–306; Wallace 1853; Denevan 1971:511; Weber 1972:2; Ruddle 1973:95). Neither the use of soldier ants nor termites appears to be very common (Bodenheimer 1951:305), although it has been reported (Wallace 1853:243; Milton 1984:14). The consumption of wasp and bee brood has also been reported for the Yukpa (Ruddle 1973:95), but does not seem to be very common.

Dietary Significance of Insect Consumption

In terms of their proximate composition the insects consumed are comparable to other animal foods. The larval and reproductive forms are also very high in fat. The fat content of the diet is generally low (Dufour 1984), and the fat in animal foods highly valued. In terms of crude protein content the insects are generally intermediate between river fish and tapir. However, the crude protein value for whole insects with hard exoskeletons, such as ants and termites, may not be an accurate measure of the biologically available nitrogen (Redford and Dorea 1984:389). The exoskeleton of these insects is partly composed of chitin, a structural, nitrogen-containing carbohydrate. Some primates are able to digest chitin (Cornelius, Dandriofosse, and Jeuniaux 1976), but it is assumed that humans can not (Taylor 1975:57), and therefore that the nitrogen in chitin is unavailable. A further consideration is that the crude protein value for termite soldiers is for whole insects and sometimes only the head is eaten, which has a higher proportion of muscle tissue to exoskeleton than the rest of the body.

The protein quality of the insects consumed was not determined. The amino acid composition of one species of Atta, A. mexicana, and four other species of insects consumed in Mexico has been reported (Elorduy de Conconi and Rodrigues 1977:168). Based on the FAO/WHO/UNU (1983) scoring pattern for the preschool child the amino acid score for A. mexicana is 54, which indicates that it is a food protein of intermediate value. Scores for the four other species ranged from 9 to 54. In all cases tryptophan was the limiting amino acid. This suggests that while the quality of insect protein is not as high as that of vertebrate protein, its amino acid composition is complementary to that in the dietary staple, cassava, which is limited in lysine and threonine (FAO 1970).

Insects were very frequently included in the diet, and during the May-June period contributed an appreciable proportion of the protein and fat derived from animal foods. They were less important in the diets recorded in November-January. The dietary records did not adequately sample seasonal differences in insect consumption, and it is likely that insects were also important in the diet when caterpillars were available in August and September. Over the entire year insects probably contributed 5% to 7% of all the animal protein consumed.
In general, insects were most often collected and consumed when other animal foods were available in very limited quantities, or not at all. This role of insects in damping fluctuations in the intake of animal foods reflected both seasonal variations in the availability of animal resources, and the day-to-day variability that occurred in individual households throughout the year. The high level of insect consumption recorded in May-June coincided with a seasonal peak in the abundance of alate ants and a relative low point in fish and game availability. On the other hand, the low levels of insect consumption recorded for November-January coincided with a period of average to exceptionally high fishing productivity. The actual availability of fish and game in individual households, however, was not completely dictated by seasonal factors. It depended to a large extent on the time and effort put into resource acquisition by males. Thus, even in January when fishing was the most productive, the diet records indicate that some households were consuming ants and termites collected by women.

The clearest difference between men and women in insect consumption is in the number of days insect material was the only animal food in the diet. This was 0 days for men and 5 of the 40 days for women. In all but one case in which the female declined the opportunity to eat fish, this sex difference was the result of differential access to animal foods. Such differential access frequently occurred when men were away on hunting/fishing trips and women remained in the village. It also occurred in the village because men did more visiting around mealtimes, and therefore were more likely to be served fish or game in a household other than their own. These male-female differences in diet may be an artifact of the village settlement where households occupy separate living structures, and may not have occurred in traditional longhouse settlements where communal meals were the norm.

Although insects were most often consumed on days when fish and game were in short supply, some forms, such as *Rhynchophorus* larvae and alate ants, were valued as delicacies in their own right and eaten both as snacks and with meals. Less valued insects, such as ant and termite soldiers, were most often eaten with meals at which no other animal foods were available or permitted. In some cases the quantity of insects eaten at meals was very small, not more than 10 to 15 termite soldiers’ heads, or a tablespoon of dry ground ants. In these quantities the insect material functioned as a condiment. It added diversity to the meal, and thereby increased the total food energy consumed. Wild nuts and seeds were often used in a similar way. This condiment function of insects is not trivial because dietary protein is only effectively used as protein when energy intake is adequate.

The diet records were kept only for individuals not subject to food restrictions, and so they do not account for the consumption of insects during such periods. Like other Tukanoans, the Tatuyo have an elaborate system of food restrictions which forms part of their medical system (see Langdon 1975 for detailed discussion). All animal and vegetable foods fit into at least one of a series of ranked categories. The highest ranked foods, the large fish and game animals, are considered potentially the most dangerous, and the first to be removed from the diet of adults in times of illness, certain life crises, or during ritual. In general insects are ranked lower than either fish or game. The most readily available insects, ant and termite soldiers, are among the lowest ranked foods, and were sometimes the only animal foods permitted in the diet. Diets limited to water, cassava starch, and termite soldiers were adhered to by adult males during male adolescent initiation rites for as long as two weeks, by menstruating females for a day or two at a time, and in some cases of illness.

**Summary and Conclusions**

Given the richness of invertebrate fauna in Amazonia (Penny and Arias 1982:222), it appears that Native Amazonians include a rather limited number of species in their diet. Those insects utilized can be characterized as being relatively large, nonpoisonous, and primarily softbodied, immature forms. In terms of their overall importance in the diet
they can be divided into two broad categories. The species contributing most energy and protein are those which form large, highly predictable aggregations: Rhynchophorus larvae, ants of the genus Atta, termites of the genus Synterms, and Noctuid and Saturniid caterpillars. These species were sought after and could be collected in considerable quantities in any one attempt. In the second group are species that are less predictable in space and time, and/or those that occurred in smaller aggregations: woodboring beetles and their larvae, wasp brood, and some caterpillars. These insects were collected opportunistically and usually in small quantities.

The composition of the insects consumed is similar to that of other animal foods. Although they are somewhat lower in crude protein and in protein quality, their amino acid composition is complementary to that of the dietary staple. Insects were frequently included in the diet and were often used to dampen fluctuations in the availability of fish and game. The dietary data presented here suggest that insects do make a significant contribution to dietary protein intake at certain times of the year.

Insects are ubiquitous in the Amazonian ecosystem and constitute a considerable portion of the animal biomass. Their inclusion in the diets of indigenous populations should not be regarded as a mere curiosity or their importance overlooked because of their small size. They are a source of energy, animal protein and fat, and can function to add diversity to the diet. Their dietary importance will no doubt vary from group to group, but the widespread practice of entomophagy warrants further attention in any evaluation of the availability of protein resources, or the adequacy of protein intake.

Notes

Acknowledgments. The Instituto de Ciencias Naturales in Bogotá under the direction of Poldoró Pinto E. provided valuable technical support during the field study. Proximate analyses of insects were provided through the kind cooperation of Franz Pardo T. of the Instituto Colombiano de Bienestar Familiar, Bogotá, and Gerardo Pérez Gómez, Departamento de Química, Universidad Nacional in cooperation with the Instituto Agropecario de Colombia, Bogotá. I am most grateful for their assistance.

For the identification of insect material I am indebted to Lloyd Knotson, Chairman, Insect Identification and Beneficial Insect Introduction Institute of the United States Department of Agriculture, and the following specialists in his division: D. M. Anderson (Coleoptera: Curculionidae, Cerambicidae, Passalidae); W. F. Barr, Cooperating Scientist (Coleoptera: Buprestidae); R. D. Gordon (Coleoptera: Passalidae, Scarabaeidae); A. S. Menke (Hymenoptera: Vespidae); D. A. Nickle (Isoptera); D. R. Smith (Hymenoptera: Formicidae); D. M. Weisman (Lepidoptera). I am also indebted to Gary Hevel of the Smithsonian Institution for his assistance with the termite material.

Grateful acknowledgment is made to the people of Yapú whose assistance made the fieldwork possible, to Paul N. Patmore for his assistance in the field, and to Michael Little for his continuing support and encouragement.

Financial support for the fieldwork in the Vaupés was provided by a dissertation fellowship from the Social Science Research Council, a grant from the National Science Foundation to M. A. Little (No. BSN 75-20169), and a postdoctoral fellowship from the Organization of American States.

1 A paper based on a preliminary analysis of some of the data presented here was read at the 48th Annual Meeting of the American Association of Physical Anthropology in San Francisco in April 1979.

2 Analyses of moisture, nitrogen, fat, ash, and crude fiber were carried out by the Instituto Colombiano de Bienestar Familiar (Coleoptera) and by the Instituto Colombiano Agropecuario (Hymenoptera and Isoptera). Both laboratories followed the standard methods of analysis of the AOAC (1950 edition of ICBF and 1965 edition at ICA) in the determination of nitrogen, fat, ash, crude fiber, and moisture. Crude protein was calculated as nitrogen times 6.25. Carbohydrate was determined by difference (100 minus the sum of water, protein, fat, ash, and crude fiber), and the energy content was calculated as 4 kcal per gram protein, 4 kcal per gram carbohydrate, and 9 kcal per gram fat. The moisture content of fresh samples was determined by drying to a constant weight in the field using traditional methods.

3 Assuming that an Atta sexdens nest contains some 5,000 queens on the day of the flight (Autuori 1950 cited in Weber 1972:53) and their average weight is 0.6 g each, a nest could contain 3,000 g
of queens. A total yield of 1,200 to 2,000 g for 10 collectors is then roughly one-half to two-thirds of the total biomass of alates in the colony.

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