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Strategic Procurement of Fish by the Pumé: A South American "Fishing Culture"

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Information is presented on fishing effort, efficiency, techniques, and catch composition for Pumé men, women, and children along with a conceptual model of fishing as a food procurement strategy. The Pumé are a native lowland South American group living in the topical savanna region of southwestern Venezuela characterized by seasonal flooding. Results are discussed in relation to the Pumé environmental and social situation, and briefly compared with results from other lowland South American groups.

KEY WORDS: fishing; techniques; efficiency; catch diversity; Pumé; South America.

INTRODUCTION

Steward's cultural ecological paradigm (1949, 1955; Hames and Vickers, 1983) has stimulated detailed study of native agriculture and hunting in South America (summaries in Beckerman, 1987; Beckerman and Sussenbach, 1983; Vickers, 1984), but one major food procurement strategy has not benefitted from a comparable analytical attention: fishing. Numerous ethnohistoric and ethnographic sources comment and briefly describe fishing practices among native groups of lowland South America (c.f. Gillin, 1936; Kirchoff, 1948; Morey, 1975; Yde, 1965), but the information is usually unsystematic and sometimes anecdotal. In this article, fishing effort, efficiency, techniques, and catch composition of Pumé men, women, and children living in southwestern Venezuela are analyzed on an annual basis. The purpose of this analysis is to generate a conceptual model of fishing to guide and to inform future functional analyses. A brief comparison is

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made of results from the present analysis of Pumé fishing to results obtained from other lowland South American groups.

BACKGROUND

Native South Americans have developed a wide range of fishing tactics to effectively exploit the abiotic complexity of lowland South America and use the diversity of fish present (Århem, 1976; Baksh, 1985; Beckerman, 1983; Denevan and Schwerin, 1978; Gragson, 1992a). Within any given South American culture, a wide range of fishing devices are typically found with the individuals using these devices being of either sex, and varying in age from children to adult. During fishing expeditions, individuals may operate as solitary actors or as members of interdependent groups variable in sex and age composition. The tactical diversity manifest in fishing is not mirrored in hunting, where the number of devices used within single cultures is typically limited; women and children almost never participate; and most hunting expeditions are conducted by solitary actors (Hames, 1989; Vickers, 1984).

The sequences of behavior expressed by individuals in procuring food result from the proximate context in which choices are made, even though the decision mechanism represents the compromise of selective pressures operating on an evolutionary time scale (Dunbar, 1989; Hurtado, 1985; Hurtado and Hill, 1990; Silby and McFarland, 1976; Stephens and Krebs, 1986; Tooby and DeVore, 1987). A functional analysis of food procurement behavior, whether proximate or ultimate, must be founded upon knowledge of the structure of the overall strategy into which particular sequences of behavior are incorporated. Although the strategy itself is best conceived as an emergent property of individual strategic action, incomplete knowledge of its structure is apt to lead to weak or insignificant results in the testing of ultimate causation (Dunbar, 1989; Koehl, 1989; Tooby and DeVore, 1987). This is because behavior is patterned by the ecological and social conditions of the moment although ultimately made possible by natural selection. The co-adapted nature of human behavioral traits suggests the structure of procurement strategies can be broken down into a series of decision compartments linked together causally to form an interdependent model (Dunbar, 1989; Tooby and DeVore, 1987). The resulting conceptual model reveals both the complexity of the system and assists in the functional analyses of links between individual compartments.

Little is known about the decision compartments associated with the strategy of fishing because of the general neglect of fishing in the study of lowland South American native subsistence (Gragson, 1992a). The first step to be carried out along with the formulation of a conceptual model is an evaluation of costs and returns of different fishing tactics. A significant amount of information is already available about the costs and returns of native hunting in lowland South America (Hames, 1979, 1989; Hill and Hawkes, 1983; Kaplan and Hill, 1985; Yost and Kelly, 1983); nevertheless, with the exception of work on certain decision compartments (e.g., prey choice, Hill, 1988; Gragson, 1991), how compartments are interrelated with strategies and incorporated into subsistence economies is still poorly understood (Beckerman, 1989; Gragson, 1992a).

ETHNOGRAPHIC CONTEXT

The Pumé inhabit a small portion of the extensive tropical savanna covering northeastern South America; the particular area they occupy is referred to in Venezuela as the *Llanos de Apure* (Fig. 1). Most Pumé now live in permanent villages along the major rivers of this area and subsist

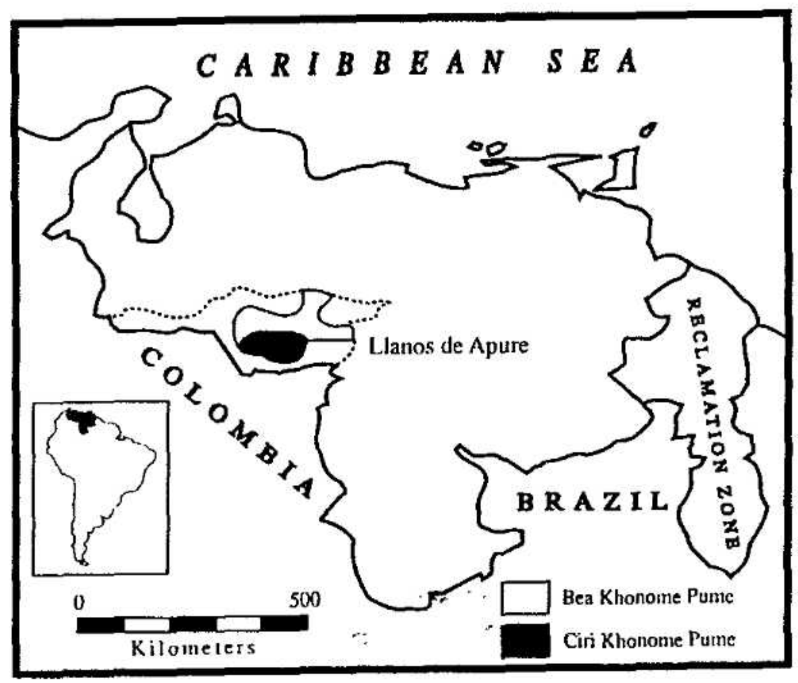

Fig. 1. Location of the Pumé within Venezuela.

on cultivation of manioc combined with foraging of vertebrate species from river courses. They supplement their diet with varying amounts of commercial products purchased with cash obtained from working as migrant laborers in agricultural areas to the north. My research and this article, however, focus on the *ciri khonome* Pumé who are a little acculturated segment of Pumé society occupying the interfluvial savanna between the Capanaparo and Cinaruco rivers. They continue to live in semi-nomadic villages, and base their subsistence on fishing, hunting, gathering of wild foods, some gardening of manioc and corn, and occasional labor for local ranchers paid-in-kind (Gragson, 1989, n.d.a).

The southern portion of the *Llanos de Apure* occupied by the *ciri khonome* Pumé receives an average annual rainfall of 2000 mm (Fig. 2). The concentration of rainfall in the months of May–October combined with the low gradient of the *Llanos de Apure* results in a temporary lacustrine condition of great importance to the fish of the *Llanos* and the Pumé (Andel and Postma, 1954; FAO, 1965; Lowe-McConnell, 1987; MAC, 1959; Machado, 1987; Mago, 1967, 1970; Zinck, 1986). Since early Colonial times, the Pumé have been characterized as "fishers" as opposed to "hunters" (Gumilla, 1970; Kirchoff, 1948; Petrullo, 1939; Rivero, 1956). A few simple statistics quantify the impressions early observers were translating into a characterization of the Pumé as fishers. Of the total amount of time dedi-

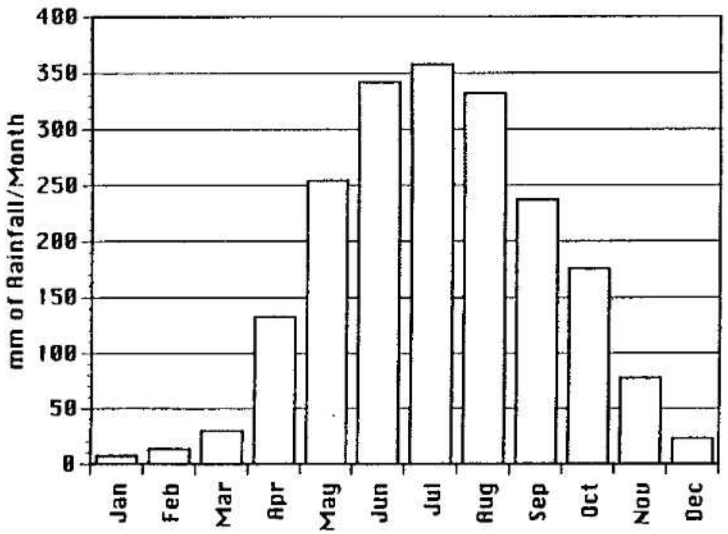

Fig. 2. Average monthly rainfall in the southern Llanos de Apure based on records from four weather stations.

cated by the *ciri khonome* Pumé to the various food procurement strategies noted above, nearly 50% is dedicated to fishing. The other five procurement strategies jointly account for the remaining 50% of subsistence effort, with each strategy accounting for 5–16% of the total subsistence effort (Table I, Fig. 3). As for nutrition, fish provide 16.9% of the kilocalories consumed on an annual basis, overshadowing game which provide 6.2%. More importantly, fish provide 64.2% of all protein in the diet, whereas game provides 18.9% (Gragson, 1989).

Table I. Subsistence Effort, Rate of Event Occurrence, and Diet Among the *Ciri Khonome* Pumé[a]

	Fish	Hunt	Collect tubers	Garden	Forage	Wage labor
Minutes per day	28.2	4.9	6.8	9.8	3.31	8.4
Daylight hours[b] (%)	3.92	0.68	0.94	1.36	0.46	1.17
Total subsistence time (%)	46.06	7.93	10.97	15.97	5.40	13.68
Daily rate of event occurrence	0.100	0.012	0.032	0.033	0.012	0.008
Kilocalories provided to total diet (%)	16.92	6.15	8.15	61.89	0.11	6.78
Protein provided to total diet (%)	64.17	18.86	3.72	9.17	0.34	3.74

[a]Adapted from Gragson (1989) and based on records for individuals 1–52 years old (see Methods).
[b]Daylight hours equal 12 hours/day.

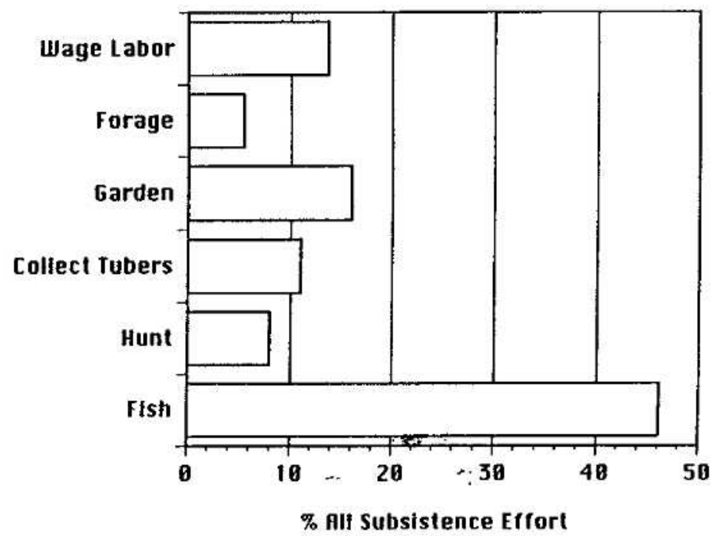

Fig. 3. Relative annual subsistence effort of Pumé men, women, and children.

METHODS

The data used in this article were collected in 1986-1987, and 1989 in a *ciri khonome* Pumé village located near the Capanaparo River. The discussion of results incorporates observations from both field trips, but only behavioral and productivity data from the first field trip are analyzed. The data derive from three sources: (1) an hourly instantaneous scan record, (2) a continuous focal record, and (3) a daily activity record.

Hourly Instantaneous Scan Record. For each week (Sunday–Saturday) of residence in the study village, 2 days were randomly selected on which scan samples at hourly intervals were made of all village members between 7:00 a.m. and 6:00 p.m. In practice, not every week was equally sampled due to unforseen events. A total of 25 days of systematic observation were made, yielding a record of 12,252 person-hours. The activity of individuals while they were in the village was coded in terms of its (immediate) consequences (Martin and Bateson, 1986), while that of individuals away from the village was coded in terms of its (future) purpose (Borgerhoff-Mulder and Caro, 1985). Purpose and consequence are effectively interchangeable on the basis of evidence collected in the numerous continuous focal observations that overlap with scan observations (Gragson, 1989).

Continuous Focal Record. Continuous records were kept on focal individuals accompanied on all manner of foraging trips. For single-individual foraging trips, selection of the focal individual was automatic. In the case of foraging groups, a focal individual was selected, but transition times (e.g., starting and stopping) and returns were noted for all members of the group increasing total sample size. Continuous information is available on 824 foraging trips, of which 464 are fishing events.

Daily Activity Record. A log of all activities taking individuals away from the study village was kept for every day of village residence. The log was made by noting who left in the morning and asking where they were going; then sometime in the late afternoon or just before people went to bed, a check was made to determine what had been brought back to camp from the morning outing and to see if any subsequent trips were made during the afternoon. For foraging trips, the resource items brought back were noted, but weights were not recorded. A total of 1491 foraging trips were recorded over a 172-day period in this log.

The lack of significant statistical differences between the three record sets either in the duration, frequency, or returns of food procurement events allowed for generating a new record set with greater coverage of the entire period of study (Gragson, 1989). (The comparisons were performed using the Z-score approximation to the Mann–Whitney *U*-test with the significance of differences being determined by the Bonferroni statistic

(α') and a family confidence coefficient of alpha = .05 [Neter et al., 1985; Sall, 1985; Siegel, 1956].) The new record set documents Pumé behavior in the study village over a 10-month time period covering the wet and dry seasons.

Four age-sex groups are used throughout this article: (adult) men 15–52 years old, (adult) women 13–50 years old, boys 7–12 years old, and girls 4–12 years old. In the calculation of fishing effort (Table II), the categories of boys and girls include children as young as 1 year of age (n = 3) since the measure is based on total activity time not just procurement activity. All other measures (efficiency, yield, and duration), however, are based on data for individuals in the age brackets noted since younger children do not participate in fishing events. For present purposes, finer age divisions are not justified. In part, this is premised on sample size constraints and the value of presenting results consistently across different measures. More fundamentally, there are no significant statistical differences in measures of fishing productivity between reproductive and postreproductive age women, or between junior and senior men when analyzed on an annual basis as they are here. The division between adults and children is taken as 13 years for cultural and analytical reasons. Culturally, it is at this age that Pumé individuals often form their first conjugal union, which is the basis of a self-sufficient household; analytically, it is at this age that children's levels of productivity in the present sample become statistically indistinguishable from adult levels (Gragson, 1989).

Fishing effort as used in this article refers to effort during daylight hours since the systematic data used to generate this measure were collected between 7:00 a.m. and 6:00 p.m. In practical terms, however, it can be used to calculate absolute effort per 24-hour period since subsistence activities very rarely take place other than during daylight hours; individuals occasionally leave the village before 7:00 a.m., but seldom return after 6:00 p.m. Fishing in particular is confined to daylight hours (unlike other lowland groups) and in over a year in the field I have recorded only two short duration (<30 min) night-time fishing events.

Table II. Individual Pumé Fishing Effort per Day and by Event Frequency

	Men	Women	Boys	Girls	Combined
Minutes per day in subsistence	101.1	32.9	52.2	4.1	57.6
Minutes per day in fishing	51.7	4.5	42.3	2.2	26.5
Daylight hours fishing[a] (%)	7.17	0.62	5.87	0.31	3.68
Total subsistence time fishing (%)	51.11	13.66	80.95	54.31	46.06
Daily rate of fishing events[b]	0.184	0.025	0.159	0.022	0.100

[a]Daylight hours equal 12 hours/day.
[b]Daylight rate multiplied by 30 equals monthly rate.

PUMÉ FISHING BEHAVIOR

Following is a brief summary of the principal results contained in the various tables along with definitions of terms. Although men show important seasonal differences in all factors of procurement (Gragson, 1990, 1992b), these differences will not be dealt with in the present analysis because they are insignificant or non-existent for women, boys, or girls.

Fishing Effort. Fishing effort is the percentage of the total amount of time (in minutes) dedicated to food procurement spent daily by individuals in fishing. Men dedicate 14.0% of daylight hours to food procurement activities and spend 51.1% of this total fishing; boys dedicate only 7.3% of daylight hours to food procurement, but spend 81.0% of this total fishing (Table II). Boys are distinguished from men by the total effort dedicated to subsistence (Mann–Whitney $U = 84$, $p = .010$, $n_1 = 10$, $n_2 = 10$), and not the effort dedicated to fishing (Mann–Whitney $U = 60$, $p = .450$, $n_1 = 10$, $n_2 = 10$). To be noted, however, is that the median age of boys in the sample is 7 years and fishing effort can include large amounts of time spent playing with their peers as they wait for the adults they have accompanied to finish fishing. Women spend 4.6% of daylight hours on food procurement, and 13.7% of this total fishing. Girls spend very little time on food procurement activities, 0.6% of daylight hours, although 54.3% of this time is dedicated to fishing. Girls are distinguished from women by the total effort dedicated to subsistence (Mann–Whitney $U = 97$, $p = .000$, $n_1 = 10$, $n_2 = 10$), and not by the amount dedicated to fishing (Mann–Whitney $U = 64$, $p = .247$, $n_1 = 10$, $n_2 = 10$).

Yield, Duration, and Efficiency. Yield is the weight of fish obtained by individuals per fishing event. Without regard for differences in age and sex, the average yield per event is 2353 gr; however, this mean is strongly influenced by the numerical prominence of cases for men—68.8% of all events. It is therefore more appropriate to consider the age and sex specific differences in yield as presented in Table III. Duration is how long fishing events last (in hours) from the moment of village departure to the moment of village return, and includes travel and search time. The mean duration of fishing events without regard for differences in age and sex is 3.9 hours although men spend an average of 4.2 hours per event, boys 3.5 hours, women 2.8 hours, and girls 3.0 hours (Table III). Efficiency is yield divided by duration. The mean efficiency per event is 655 gr/hr, with men achieving the highest efficiency of the four age-sex groups at 772 gr/hr. Women and girls achieve means approximately 200 gr less than men, while boys attain a mean 400 gr less (Table III). Boys have a low efficiency for this technique due in part to miscasting and probably more directly to the frequency with which they cast into shallow water where only small fish are to be found.

Table III. Yield, Duration, and Net Efficiency of Pumé Fishing Events

	Men	Women	Boys	Girls	Combined
Weight per event in grams[a]					
Mean	2808	1685	1271	1723	2353
Std. dev.	2622	1155	1248	1153	2378
n	289	15	107	9	420
Time per event in hours					
Mean	4.16	2.77	3.47	2.95	3.87
Std. dev.	2.23	0.81	1.99	0.87	2.14
n	259	16	123	9	407
Efficiency per event in gr/hour					
Mean	772	550	354	535	655
Std. dev.	698	260	389	257	640
n	252	15	89	9	365

[a]Gutted weight of fish.

Fishing Techniques and Their Efficiency. The Pumé use four different fishing techniques over the course of a year. In order of use-frequency, they are: hook-and-line fishing, poison fishing, bow-and-arrow fishing, and spear fishing (Fig. 4). Hook-and-line fishing consists of handcasting steel hooks and nylon monofilament[2] from lake shores or river banks; as bait, the Pumé often start by using earthworms and then cutting up for bait the first fish caught. Hook-and-line fishing accounts for 49.8% of all fishing events with men performing 30.2% and boys performing the remaining 19.6% (Table IV). Men have an efficiency using this technique of 783 gr/hr while boys have an efficiency of 335 gr/hr (Table V); the difference is statistically significant (Mann–Whitney $U = 6379$, $p = .000$, $n_1 = 126$, $n_2 = 66$). Women and girls do not generally engage in hook-and-line fishing.

Poison fishing is carried out with roots from the cultivar *Tephrosia sinapou* or the tuber of a wild yam (*Dioscorea* spp., Gragson and Tillett, n.d.). It accounts for 26.3% of all fishing events and is the only technique that men, women, and children all practice. Men undertake 12.7% of all poison fishing events and are followed in order of frequency by boys at 8.2% of events, women at 3.5% of events, and girls at 1.9% of events (Table IV). Men have an efficiency using this technique of 1050 gr/hr, boys of 445 gr/hr while women and girls have an approximate efficiency of 550 gr/hr (Table V). Poison fishing is 1.3 times more efficient than hook-and-line fish-

[2]The use of hook and line for fishing by the Pumé may not simply be an artifact of contact. The Makuna, for example, who now use steel hooks and nylon monofilament, traditionally made line from palm fiber (*Astrocaryum* spp.) and hooks from palm spines (*Guilielma* taxon) (Århem, 1976). The Pumé use numerous palm products today (Gragson, 1992c) and may have manufactured hook-and-line from palm products like the Makuna during a time when steel and nylon were not available.

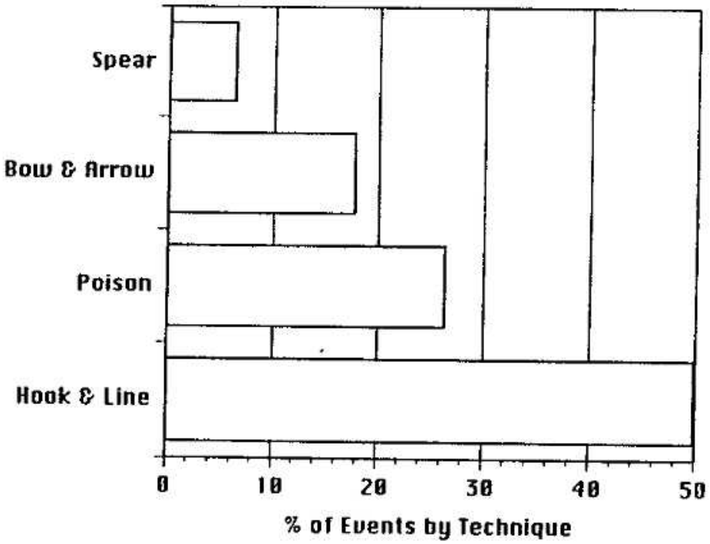

Fig. 4. Relative annual use-frequency of Pumé fishing techniques.

Table IV. Relative Frequency of Use of Pumé Fishing Techniques (% of All Events)

	Men	Women	Boys	Girls	Row total
Hook and line	30.17	0.00	19.61	0.00	49.78
Poison	12.72	3.45	8.19	1.94	26.30
Bow and arrow	15.52	0.00	2.16	0.00	17.68
Spear	5.60	0.00	0.65	0.00	6.25
Column total[a]	64.01	3.45	30.61	1.94	100.01

[a]Rounding error accounts for departure from 100.00%.

ing for men and boys, although the difference is statistically significant only for men (Mann–Whitney: men: $U = 1480$, $p = .011$, $n_1 = 126$, $n_2 = 33$; boys: $U = 443$, $p = .052$, $n_1 = 66$, $n_2 = 19$).[3]

Bow-and-arrow fishing is performed most often from platforms associated with dams built across rivers. It accounts for 17.7% of all fishing events and men are the most common practitioners undertaking 15.5% of all events (Table IV). Boys (generally older boys) account for the other

[3]Poison fishing events are communal and individuals, particularly when members of a family group, frequently pool their returns. The input value for analysis in the case of pooling was the total weight of a catch divided by the number of individuals pooling their catch. Statistical means for this technique are only an approximation of the real value and since individual returns are dependent variables, differences between age-sex groups cannot legitimately be tested for significance.

2.2% of the annual total; women and girls do not use bows and arrows. Bow-and-arrow fishing has the lowest efficiency of any technique for men who are the only age-sex group with a sufficient number of cases to perform the test of significance (Table V). The three possible comparisons (bow-and-arrow:hook-and-line; bow-and-arrow:poison; bow-and-arrow:spear) all have Mann–Whitney U-test p-values $< .000$.

Spear fishing consists of thrusting a pair of very long arrows repeatedly into a shallow river pond. It accounts for only 6.3% of all fishing events and is practiced exclusively by men and (older) boys. Men undertake 5.6% of all events while boys account for the remaining 0.7% (Table IV). Men have an efficiency using this technique nearly double what they have in poison fishing ($U = 294$, $p = .039$, $n_1 = 33$, $n_2 = 26$) and over 4.5 times greater than what they have in bow-and-arrow fishing ($U = 837$, $p = .000$, $n_1 = 126$, $n_2 = 26$). Boys, however, obtain their lowest overall efficiency using this technique (Table V).

Catch Composition. The Pumé take at least 43 culturally defined species of freshwater fish in 15 families and six orders (Table VI). (Not all culturally defined species have been taxonomically identified at the species level.) Characids were obtained on 53.4% of fishing events and are the most frequently recorded order of fish (Table VII). The two sets of values presented in Table VII are not directly comparable as they are based on different units, but they do suggest the Pumé rely more heavily on Percids and Characids, and less on Silurids and Gymnotids than the biotic representation of species in these four orders suggests.

Table V. Net Efficiency of Pumé Fishing Techniques in gr/hr

	Men	Women	Boys	Girls	Combined
Hook and line					
Mean	783	—	335	—	629
Std. dev.	611	—	412	—	589
n	140	—	66	—	192
Poison					
Mean	1050	550	445	535	739
Std. dev.	574	260	333	257	513
n	33	16	19	9	76
Bow and arrow					
Mean	315	—	73	—	311
Std. dev.	378	—	—	—	377
n	67	—	1	—	82
Spear					
Mean	1544	—	281	—	1413
Std. dev.	975	—	78	—	1001
n	26	—	3	—	29

Table VI. Fish Species Used by the Pumé[a]

Pumé name	Family	Genus species	Common name
akučiguDaDeme	CHARACIDAE	*Acestrorhynchus* sp.	Characin
ñunapea	CHARACIDAE	*Acestrorhynchus* sp.	Characin
ñionoókaDa	CICHLIDAE	*Aequidens* sp.	Cichlid
mODO	CTENOLUCIIDAE	*Boulengerella* cf. *lucia*	Pike characin
hoŋo	CHARACIDAE	*Brycon* sp.	Characin
guiteõ	CHARACIDAE	*Bryconops* cf. *caudomaculatus*	Characin
očonočõ	CHARACIDAE	*Brycon* cf. *falcatus*	Characin
čõyåbihuDaDeme	CHARACIDAE	*Catoprion mento*	Characin
čumi	CICHLIDAE	*Cichla ocellaris*	Cichlid
yakhaDa	CICHLIDAE	*Cichla ocellaris*	Cichlid
ŋoečõ	CICHLIDAE	*Cichla temensis*	Cichlid
ñionoóčha	CICHLIDAE	*Cichlasoma bimaculatum* ?	Cichlid
ñionoõ	CICHLIDAE	*Cichlasoma bimaculatum* ?	Cichlid
tojĩDi	CICHLIDAE	*Cichlasoma* cf. *bimaculatum*	Cichlid
akũndeDo	CICHLIDAE	*Cichlasoma festivum*	Cichlid
abO	CICHLIDAE	*Cichlasoma severum*	Cichlid
tobokɛDia	CICHLIDAE	*Crenicichla* sp.	Cichlid
yačhučhu	CICHLIDAE	*Crenicichla* sp.	Cichlid
yaikoDoDeme	CICHLIDAE	*Crenicichla* cf. *geayi*	Cichlid
čie	ELECTROPHORIDAE	*Electrophorus electricus*	Electric knifefish
pundičaDa	CICHLIDAE	*Geophagus daemon*	Cichlid
naphuphu	CICHLIDAE	*Geophagus jurupari*	Cichlid
õDõ (patú)	GYMNOTIDAE	*Gymnotus carapo*	Naked-back knifefish
yagupae	ERYTHRINIDAE	*Hoplerythrimus unitaeniatus*	Trahira
dapue	ERYTHRINIDAE	*Hoplias malabaricus*	Trahira
ičOa	CALLICHTHYIDAE	*Hoplosternum littorale*	Armored catfish
itonome	CALLICHTHYIDAE	*Hoplosternum thoracatum*	Armored catfish
dahuru	*CYNODONTIDAE	*Hydrolicus scomberoides*	Characin
ipea	ANOSTOMIDAE	*Leporinus* cf. *friderici*	Anostomid
hiβe	LORICARIIDAE	*Loricaria* sp.	Armored catfish
aphai	CHARACIDAE	*Metynnis* sp.	Characin
dakičõ	CICHLIDAE	*Petenia* ?	Cichlid
kɨDi	MOCHOKIDA	*Platydoras armatulus*	Upside-down catfish
kuina	POTAMOTRYGONIDAE	*Potamotrygon hystrix*	River stingray
hie (čɨɨ)	CHARACIDAE	*Pristobrycon striolatus*	Characin
pačõngoanti	PIMELODIDAE	*Pseudoplatystoma fasciatum*	Whiskered catfish
hiβe	LORICARIIDAE	*Pterygoplichthys multiradiatus*	Sucker-mouth catfish
hondɛčõ	CHARACIDAE	*Pygopristis denticulatus*	Characin
ɛDɛ	PIMELODIDAE	*Rhamdia* sp.	Whiskered catfish
yačõya	CURIMATIDAE	*Semaprochilodus kneri*	Curimatid
ỌdO	SYNBRANCHIDAE	*Synbranchus marmoratus*	Swamp eel
tophundatoDo	PIMELODIDAE	*Tympanoleura* ?	Whiskered catfish?
beDo	*PIMELODIDAE	?	Whiskered catfish?

[a]Starred (*) families are tentative identifications by the author, all others identified by Antonio Machado, Instituto Tropical (UCV), Venezuela.
[b]Phonetic transcriptions are in accord with Pullum and Ladusaw (1986).

Table VII. Catch Composition of Pumé Fishing Events and Biotic Composition of the *Llanos* Fish Fauna by Taxonomic Order

	Catch composition[a]	Biotic composition[b]
Characiformes	53.38	39.64
Siluriformes	4.05	32.54
Perciformes	37.16	8.88
Rajiformes	1.01	0.59
Gymnotiformes	0.68	11.83
Synbranchiformes	3.72	0.59
Other[c]	0	5.92

[a]Number of individuals per catch in a given order.
[b]Number of species in an order based on Machado (1987).
[c]Includes Clupleiformes, Atheriniformes, and Pleuronectiformes.

DISCUSSION

The Pumé use fishing techniques according to changes over the course of a year in the depth of landscape inundation, which are associated with changes in the standing biomass of fish and the faunal composition of fish habitats (Machado, 1987; Mago, 1967, 1970; Winemiller, 1989). Fishing effort itself is negatively correlated with monthly rainfall, while all other food procurement strategies have positive correlations with rainfall (Gragson, 1989, n.d.b). When the level of landscape flooding reaches its peak of about 100 cm in the area of the *Llanos* occupied by the Pumé, the expected efficiency for fishing is around 225 gr/hr without regard for age and sex related differences; when water levels in river ponds are at a minimum, the expected efficiency rises to about 900 gr/hr. More generally, bows and arrows are used during the period of maximum flooding, hooks and lines during the period of receding flood, poison during the early dry season, and spears during the late dry season (Gragson, 1990). The Pumé group themselves for fishing according to (1) the skill needed to use a particular technique, (2) the effect several fishers have on a single habitat during a given event, (3) the effect multiple events have on standing biomass of fish in a given habitat, and (4) Pumé perceptions about personal hazard associated with certain types of events.

The Pumé practice bow-and-arrow fishing most often from platforms within the gallery forest. To reach a fishing platform, an individual wades through water up to 1.5 m deep, entailing personal danger from the swift current and the possibility of meeting a caiman. Once in position, a fisher must wait in a confined space until a fish swims within 2–8 m; this seems to be the range at which a successful strike can be made given water refraction and height of platforms. The long wait, lack of mobility, and level of skill needed for hitting a fish with an arrow seem to preclude most boys (certainly younger ones) from practicing this technique. The element of personal danger is also important in limiting this particular fishing technique to men. Bow-and-arrow fishing is practiced during the height of the flood season and its effect on subsequent fishing events is minimal since the fish harvested are readily replaced with individuals from the flooded hinterland. This is largely possible because fries and juveniles are numerically most important in the population at this time of year (Machado, 1987) and they are not affected by this technique.

Individual Pumé may go hook-and-line fishing alone, but often go in groups and split up once they arrive at the fishing site. Hook-and-line fishing sites are frequently at substantial distances from a village, as reckoned by Pumé standards (7–12 km roundtrip). When fishing in small river ponds (50–2000 m^2), the catch of one fisher will affect that of another, no recruitment of fish is possible until the next flood cycle is complete, and the success of all subsequent fishing events in this pond will be affected by those preceding it. When fishing in lakes (up to 40,000 m^2), individuals spread out along the shore, and each fisher's catch minimally affects the catch of other fishers; in addition, the number of fish will be large enough that the effect of multiple events will not be noticeable before stocks are replenished during the next flood cycle. Pumé often come into contact with *criollo* cattle ranchers during hook-and-line fishing events. Cattle ranching and cheese manufacturing are the principal *criollo* enterprises in this area of the *Llanos*, and cheese stations are commonly located on lakes and large river ponds since drinking water for the cows is a limiting factor to cheese production during the dry season (Carvallo, 1985; Tamayo, 1987). The Pumé perceive cheese stations as a threat to their subsistence and voice this concern by frequently remarking on the quantity of fish the *criollos* take for their personal consumption. *Criollos* see the Pumé as a threat to their way of life also, because they believe Pumé fish poison kills their cattle (Gragson, n.d.a). Older boys fish in river ponds within sight of a village, but they will not go to distant sites unaccompanied (usually by their fathers). When boys fish ponds within sight of a village, they are exploiting a habitat that experiences heavy use and the number of fish are much lower than in more distant sites. Distance and the avoidance of contact with *criollos* seems to account most directly for the lack of participation in hook-and-line fishing events by women and young children.

Poison fishing involves little skill since fish are simply "gathered" from the surface of the pond after the poison takes effect. Since the technique involves walking through a pond, however, it carries the risk of stepping on a freshwater stingray (*Potamotrygon hystrix*). The Pumé often comment on this risk when they poison larger ponds with no forest cover and up to 1.5 m deep. During the 1986–1987 field season, a man and a women stepped on stingrays, and the swelling and pain confined the man to his hammock for approximately 10 weeks and confined the women for about 3 weeks. Women and children seldom participate in the poisoning of deep river ponds, but actively participate in poisoning small feeder streams or shallow ponds deep in the gallery forest. Feeder streams are usually very clear and no more than 20–30 cm deep; forest-covered ponds may be up to 1 m deep, but lie in deep shade and the water has a high content of plant leachates (Machado, 1987). Stingrays are not seen in these two contexts nor do the Pumé voice concern over encountering them. Catch returns per individual in poison fishing are interdependent since everyone is working the same pond; each poison fishing event also affects all future events in a given pond because no restocking will occur until the next flood cycle is complete. Shallow streams and gallery forest ponds are seldom fished again after poisoning because the fisk stock is completely harvested, but large river ponds are subsequently fished by hook and line and more commonly by spear. Different fishing techniques may be used on the same pond because each technique affects faunal composition of the pond differently (Lowe-McConnell, 1964; Welcomme, 1979). For example, fish differ in their physiological ability to tolerate anoxia resulting from eutrophication or poisoning (Machado, 1987; Winemiller, 1989).

Spear fishing involves a group of men wading through shallow water (<1 m) and blind-thrusting a pair of arrows underhand until a fish is hit. With this technique, all fish remaining in a previously poisoned river pond are systematically harvested and the pond will not be fished again until the next flood cycle is complete. The Pumé voice some concern of stepping on a stingray while spear fishing, but the risk is apparently lessened by a previous poisoning. A greater risk is probably being speared by someone else since as many as 6 men may be simultaneously spearing in a pond no bigger than 10 m in diameter and 80 cm deep. Dramatic individual efficiencies are attained with this technique because of its systematic nature and its application to ponds where the number of fish has reached an annual maximum due to the concentrating effect of landscape desiccation (Lowe-McConnell, 1964; Machado, 1987; Mago, 1970). Rhythm of thrusting (regularity and speed) as well as knowing how to retrieve a fish once speared are important to the success of this technique. The arrows used are up to 2.5-m long, unbarbed, and must be held so that once a fish is hit it will not slip back off the point. Boys appear to have a low efficiency using this technique because they thrust their arrows at a slower rhythm than men and have greater difficulty retrieving fish.

The Pumé have certain preferences and beliefs about different species of fish that influence fishing behavior and catch composition yet go beyond the effects of environment, choice of technique, and grouping of people. *Hoplias malabaricus* and *Cichla ocellaris* are two highly-favored species for their flavor and because they can be smoked and stored for several days; *Cichla ocellaris* also has ritual use. The electric eel (*Electrophorus electricus*) is seldom caught probably due to its nocturnal habit (Low-McConnell, 1964; Machado, 1987), but is favored like *Cichla ocellaris* for its flavor and its use in ritual. The freshwater stingray is eaten during the height of the wet season "because it is fat" as the Pumé say, but during the rest of the year they are killed and discarded after taking the tail barb for ritual use. When either Loricarid (*Loricaria* sp. and *Pterygoplichthys multiradiatus*) is caught, they are given to an old person for their consumption or simply discarded.

Adult Pumé values for fishing effort and efficiency fall comfortably within the range of variation recorded for lowland South American groups. The average daily percentage of time dedicated to fishing by men and women in 13 lowland groups is 2.4% with a range from 0% to 4.9% (Hames, 1989). Pumé men and women dedicate on average 2.0% of their day to fishing (3.9% of daylight hours). The combined mean fishing efficiency of adult men and women in a sample of seven lowland groups is 320 gr/hr with a range from 50 gr/hr to 680 gr/hr; the efficiency for men in a sample of ten lowland groups is 570 gr/hr with a range from 131 gr/hr to 2120 gr/hr (Hames, 1989). Pumé men and women combined have a mean fishing efficiency of 655 gr/hr, while men achieve an efficiency of 772 gr/hr. Comparative information on children's involvement in subsistence is almost non-existent for lowland South America and the ethnological place of Pumé children is unknown.

Other comparisons between the Pumé and lowland South American groups are more difficult to make because information on fishing is poorly reported, and the particulars of fishing are frequently implied, but not often stated. The Pumé do not seem to use as many fishing devices as some lowland South American groups are reported to use (e.g., Århem, 1976; Yde, 1965), but variation in fishing group formation is comparable since for some lowland groups it is known that fishing devices are used by parties varying in size, age, and sex composition (Baksh, 1985; Beckerman, 1983; Denevan and Schwerin, 1978). Unfortunately, little is known about how or when throughout the year groups use the various fishing techniques available to them. Native groups seem to use large numbers of fish species (Århem, 1976; Baksh, 1985; Denevan and Schwerin, 1978), but unlike game, fish are commonly lumped into a single lifeform so the reasons for species-richness and its relation to patterns and techniques of exploitation are generally unknown. Finally, natives in lowland South America exploit a wide variety of fish habitats (Århem, 1976; Chernela, 1985, 1989; Stocks, 1983), and even though this is one of the most important aspects of native fishing, it is also one of the least studied.

The structure and organization of food procurement strategies like fishing reflect the life history characteristics of the fish used; the inherent scaling of ecosystem processes such as landscape development, rates of production, and changes in habitat; and the risks and rewards associated with fishing techniques and tactics (Beckerman, 1983; Chernela, 1989; Cummins, 1988; Frost and Miller, 1987; Gragson, 1992a; Moran, 1990; O'Neill, 1989; Räsänen et al., 1987; Schindler, 1988). If the structure, organization, and, by extension, function of fishing is to be understood and not simply described, then greater attention needs to be given to these different parameters. Figure 5 presents a conceptual model of fishing that incorporates the parameters identified throughout this discussion as significant to the overall success of fishing as a food procurement strategy. On the left or cultural side of this model, each compartment can be considered a "decision gateway" through which individuals must pass in going from the fishing technology initially selected on towards the final goal of the procurement event. Eventually it should be possible to assign weights to the indicated directions in order to make a realistic model of food procurement behavior that transcends both monocausality and environmental determinism.

CONCLUSION

In the discussion of human foraging in lowland South America there has been a general failure to recognize either the importance of fish to native subsistence or the scaling inherent to natural and human ecosystems. Fish are widely available and used year-round as a food resource by native groups. Individuals simply compensate for changes in fish density resulting from changes in water volume and fish habitats by adjusting their procurement tactics. Overall, fish appear to be more dependable as a food resource than game because fish are significantly more abundant *in time* and productive *over time* than game (Beckerman, 1989; Gragson, 1992a). What is currently needed to better understand fishing as a procurement strategy as well as understand its relation to other procurement strategies in native subsistence economies is information comparable in detail to what is currently available on hunting tactics and strategies (e.g., Hames, 1979, 1989; Hawkes, 1990; Hill and Hawkes, 1983; Kaplan and Hill, 1985; Yost and Kelly, 1983). This is particularly true if human choice between alternative food procurement strategies and their incorporation into subsistence economies are the objective of study (Gragson, n.d.a, 1991; Hill, 1988; Smith, 1991).

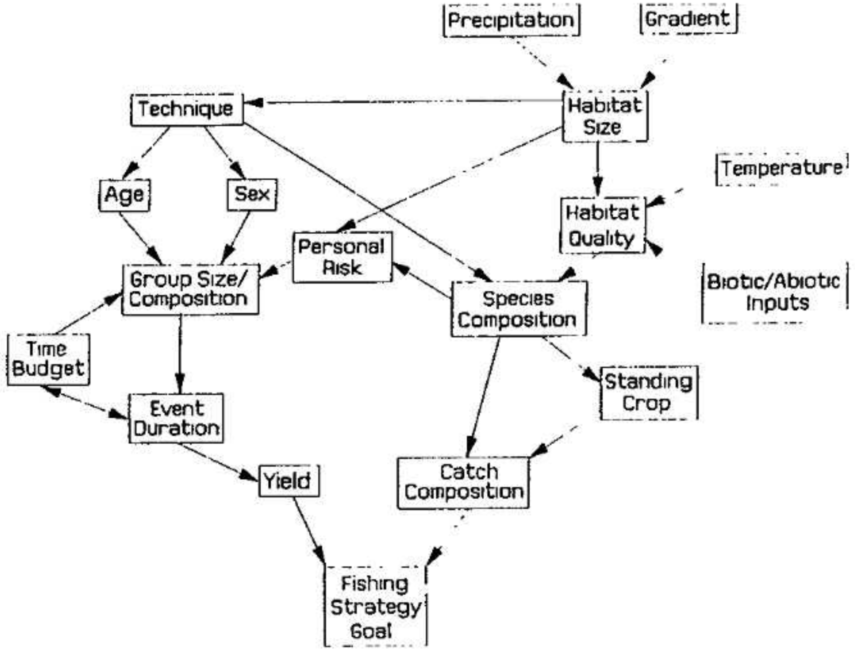

Fig. 5. Conceptual model of fishing as a food procurement strategy.

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