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EFFECT OF PCB (AROCLOR 1254) ON REPRODUCTION, BEHAVIOR, AND SURVIVAL OF *HYDRA VIRIDIS*

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ABSTRACT

Survival, behavior, and reproduction of *Hydra viridis* was studied in animals treated with the polychlorinated biphenyl mixture (PCB), Aroclor 1254. PCB was administered as a component of the culture medium (artificial pond water) in concentrations varying from 0.2 mg/1 to 100.0 mg/1 PCB. Reagent grade acetone was employed as a carrier for the PCB due to its low solubility in water. Control animals were maintained in a 250.0 mg/1 acetone culture medium.

Aroclor 1254 was lethally toxic to *H. viridis* with concentrations of 20.0 mg/1 producing 100% mortality after a 24 hour exposure. Sublethal PCB concentrations as low as 2.0 mg/1 caused lethargic behavior and decreased feeding. Reproduction was suppressed in concentrations as low as 0.2 mg/1, and morphological abnormalities occurred at PCB levels of 2.0 mg/1 or greater.

INTRODUCTION

This investigation studies the effects of the polychlorinated biphenyl mixture (PCB), Aroclor 1254, on the survival, behavior, and reproduction of *Hydra viridis*. A polychlorinated biphenyl molecule is composed of the biphenyl radical as its molecular backbone, with varying numbers of attached chlorines. There are 210 possible chlorine arrangements for these compounds. The degree of chlorination determines the chemical and physical properties of the Aroclors; the first two digits of the numbered Aroclor represent the molecular type (*12*54), the last two digits the average percent chlorine in the mixture (12*54*). The physical state of the PCBs varies from colorless oily liquids in the lower chlorine series to black resins in the higher series. These compounds are not readily biodegradable. Resisting breakdown by water, acids, or alkalis, they are not readily miscible with water, and have a boiling point ranging from 278 to 475°C (Oerberg et al., 1972).

PCBs are widespread in the environment, with a frequency of occurrence rivaling that of DDT (Risenbrough and Bodine, 1970). The significance of PCBs as

Nebeker et al., 1974; Duke et al., 1970; Merson and Kirkpatrick, 1976), and fish food organisms (Maki and Johnson, 1973).

PCBs, like their chemical relatives DDTs, are toxic to a large range of animal life, including humans (Dursuma and Marchand, 1974; Fisher, 1975; Halter, and Johnson, 1974; Kerkvliet and Kimeldorf, 1977; Platonow and Karstad, 1973; Mosser et al., 1972; Nebeker et al., 1974). The effects of PCBs include decreased growth in rats (Kerkvliet and Kimeldorf 1977), reduced litter sizes in pigs (Hansen et al., 1975), inhibition of reproduction in mink (Platonow and Karstad, 1973), increased length of estrous cycles in white mice (Oerberg et al., 1972), decreased blastocyst implantation efficiency in sea lions (Delong et al., 1973), and a decreased rate and ability to regenerate in planarians (Dursuma and Marchand, 1974).

In this study the effects of PCBs on behavior, morphology, and budding in *Hydra viridis* is examined. The budding ability of the offspring of PCB treated parents are also investigated. This study represents the first investigation into the effects of PCBs on a coelenterate. Of added significance is the fact that *Hydra* are fresh water organisms, and that most aquatic studies have been done on marine species (Peakall, 1975).

Hydra is a very desirable subject for this type of study due to its rapid reproduction time as well as its simple anatomy. The animal is essentially one continuous epithelium attached to a non-living substratum (mesoglea). The epithelium of *Hydra* reflexes upon itself at the hypostome, forming what is generally referred to as the diploblastic anatomy of the animal (Adams, 1975). As a result all of the animal's cells are in contact with its aqueous environment, making treatment of *Hydra* with exogenous compounds as simple as exposing a tissue culture to such compounds, i.e., the substances can be administered as a component of the medium.

MATERIALS AND METHODS

Animals used in this study were cultured at 19± 1°C both prior to and during experimentation. All animals were fed six days per week using *Artemia* sp. nauplii, and the culture medium

Culture medium for control animals was composed of 250 mg/1 acetone in artificial pond water. The 250 mg/1 acetone level in the control medium was a greater final concentration of aceton than that of any experimental group. Acetone levels in experimental media ranged from 240.0 mg/1 in the 100 mg/1 PCB concentration to 12.0 mg/1 in the 0.2 mg/1 PCB (Lawson, 1978).

Two groups of ten animals were employed with each of the five concentrations of PCB used in the toxicity tests, thus twenty animals were exposed to each concentration used. For sublethal studies, each animal was kept in an individually numbered Petri dish, twenty per concentration. Each animal in the sublethal test group was observed at six-hour intervals until buds were initiated. Once a bud had reached thirty-six hours of development, bud detachment was monitored at two-hour intervals.

Behavioral data were taken daily at feeding time for the sublethal treatment group. Mobility and reactivity of the animals were tested tactilely using watchmaker's forceps, prior to giving the animals *Artemia*. For the first five minutes following exposure of an animal to *Artemia*, hydras' ability to capture prey was observed. During the next thirty minutes frequent observations were made of each animal to determine whether *Artemia* were ingested. These observations were taken for a period of six days. Identical data were gathered for control animals.

The Chi square statistic was used to test the significance of differences obtained. In computing Chi square, the average of the frequencies (whose difference is to be tested) was employed as the expected value. The degrees of freedom were one less than the number of frequencies in any test. Pearson's Product-Moment Correlation Coefficient was used in determining the relationship between PCB concentration and budding.

RESULTS

Toxicity tests were performed in order to find a sublethal concentration of PCB to be used in subsequent behavioral and developmental studies. Our results showed that PCB concentrations of 100.0, 80.0, 60.0, 40.0, and 20.0 mg/1 all caused 100 percent mortality when the animals were exposed for 24 hours. One hundred percent of the animals survived in the 10 mg/1 PCB concentration.

Sublethal toxic effects were observed for PCB concentrations of 10.0, 6.0, 2.0, and 0.2 mg/1. After 24 hours of exposure to concentrations of 10.0 mg/1, 6.0 mg/1 and 2.0 mg/1, the hydras became depressed and did not consume *Artemia* (depressed animals are also distinguished by shortened tentacles and general lack of responsiveness to stimuli). Some of the animals were able to capture prey but lacked the ability to consume it. All animals treated at a concentration of 0.2 mg/1 captured prey, and 55% of the hydras were observed to consume *Artemia* after 24 hours. However, most of the *Artemia* were egested or held within the gastrovascular cavity, with only partial digestion in either case.

Most of the animals in the 10.0, 6.0 and 2.0 mg/1 PCB concentrations displayed lethargic tentacle and body movements and an almost constant dilation of their hypostomes. Retardation became more progressive throughout the entire test period for animals in 10.0, 6.0, and 2.0 mg/1 concentrations.

Depression was the only abnormal behavior noted for the organisms in the 0.2 mg/1 PCB treatment group; this effect was noted on the last day of treatment. A significantly lower frequency of depressed animals was observed when the 0.2 mg/1 group (20%) was compared to the average for the higher concentrations (80±10%), $.005>p$. The rate of movement in the 0.2 mg/1 treatment group did not appear to differ from either untreated or acetone-treated control animals. Responsiveness to light and touch was also normal.

Morphogenic effects of sublethal PCB concentrations are presented in Table 1. PCB affected bud initiation and detachment, bud morphogenesis and morphology, and the ability of buds formed on PCB treated parents to feed and/or reproduce following detachment from the parent. Bud initiation and detachment were significantly depressed by all concentrations used in this study, $.005>p$ for all concentrations (Table 1).

TABLE 1. *Effects of Aroclor 1254 on Budding in Hydra viridis*

Conc. of PCB mg/1	# of Animals	% Bud initiation	% Bud Completion	Mean developmental time for buds: days (hrs.)
0.0 (Control)	20	100	100	2.15 (52)
10.0	20	25*	5*	2.04 (49)
6.0	20	0*	0*	N/A
2.0	20	0*	0*	N/A
0.2	20	30*	30*	1.59 (38)

N/A: Not Applicable; *: Significantly different from controls ($p < .005$)

Buds were initiated in the 10.0 mg/1 and 0.2 mg/1 PCB concentrations only (25% and 30% respectively). The 6.0 mg/1 and 2.0 mg/1 treatment group showed no bud initiation. When Pearson's Moment Correlation Coefficient was employed to determine the relationship between increasing concentrations of PCB and decreasing bud initiation a weak negative correlation was shown ($r= -0.13$).

Bud detachment was observed for only 5% (one animal) of the animals in the 10.0 mg/1 treatment group compared to 25% of the hydras in this group showing bud initiation. Buds initiated on four 10.0 mg/1 PCB treated animals did not develop completely, nor did they detach from parent organisms. Instead, these buds disintegrated along with the parent organisms between 2-4 days after the 6 day treatment period. No recovery from PCB treatment was observed.

Buds initiated in the 0.2 mg/1 treatment group (six animals) underwent normal morphogenesis and detached from parent animals (Table 1). The buds formed on PCB treated parents were assayed for morphology, behavior, and reproductive ability following their detachment from parent animals.

One bud developed at 10.0 mg/1; this bud displayed an abnormal morphology, with short underdeveloped tentacles. The body neither contracted nor elongated in response to tactile stimuli, and no feeding behavior or reproduction was observed. One hundred percent of the buds formed in the 0.2 mg/1 concentration displayed normal morphology and feeding behavior. However, none of these animals were able to reproduce (Table 2).

TABLE 2: *Effects of Aroclor 1254 on the Behavior of Buds Developed on PCB Treated Parents*

Conc. of PCBs	% Buds Displaying Feeding Behavior	% Buds Capable of Reproduction
0.0	100	100
0.2	100	0
10.0	0	0

Discussion

Our experiments indicate that Aroclor 1254 is lethally toxic to *Hydra viridis* at 24 hour exposures, with concentrations as low as 20.0 mg/1 producing 100% mortality after a 24 hour exposure. Notably, 100% survival is seen with 10.0 mg/1 PCB, showing a high tolerance of the hydras to PCB exposure. PCB concentrations are lethal to most invertebrates tested in microgram/1 concentrations (Peakall, 1975).

Sublethal concentrations of PCBs are shown to affect behavior in these animals in concentrations as low as 2.0 mg/1. Retarded movements, failure to capture prey, failure to ingest prey and constantly dilated hypostomes are observed. These effects resemble those seen following treatment with reduced glutathione (Adams, 1975) and thus suggest damage to the animals' nervous systems. Garcia (1979) reports that PCBs affect the neuroanatomy of *Brachydania rerio.*

Reproduction is significantly suppressed in all PCB treated groups. Furthermore, none of the buds formed in the presence of PCBs have the ability to reproduce.

Shostak et al. (1968) concludes that budding is directly related to feeding in *Hydra*. Schaller (1976) shows that feeding is actually a stimulus for the release of a polypeptide responsible for mitogenic activity in *Hydra*. Thus, the direct control for budding appears to be the rate of mitosis; growth in *Hydra* would likewise be controlled (Schaller, 1978). Shostak et al. (1968) supports this line of reasoning by concluding (p. 423) that, . . . "bud initiaton depends on the parental production of a quantum of cells which can completely support the further development of a bud."

It appears then, that one effect of sublethal concentrations of PCBs is to prevent cell divisions, and thus, prevent growth and reproduction in *Hydra*. Reports by other investigators support the contention that Aroclor 1254 inhibits growth and reproduction in other organisms, eg., *Euglena gracillis* (Bryan and Olafsson, 1978); *Peromyscus leucopus* (Merson and Kirkpatrick, 1976); Walker 256 carcinoma (experimental tumor) in rats (Kerkvliet and Kimeldorf, 1977); hermit crabs (Stahl, 1979); and fertilized *Arbacia* eggs (Adams et al., 1980). James (1980) shows abnormal mesogleal formation in the area of the potential budding region of PCB treated hydras; as well as a lower mitotic index.

Since feeding is the normal stimulus for release of the mitogen in *Hydra* (Schaller, 1976), it would appear that animals treated with 0.2 mg/1 PCB should have continued to bud in light of the fact that feeding behavior is normal in these organisms. However, food consumed by these animals is observed to be egested in a state of partial decomposition (0.2 mg/1 treatment), or in some instances simply held inside the gastrovascular cavity (2-10.0 mg/1). Thus, in *Hydra viridis* PCBs may interfere with digestion and absorption of foods in addition to affecting mitosis.

Yap et al. (1971) finds PCBs to be effective inhibitors of ATPase activity. This effect would be expected to eventually halt all biological oxidation reactions of the intracellular digestive processes via end-product feedback inhibition. It is possible that PCBs affect other enzymes directly involved in biological oxidation or other cellular activities. No data exists to support such a notion, however, the liver is a major target of PCBs in higher organisms (Yap et al., 1971). Komives (1979) reports that Aroclor 1254 reduces the basal metabolic rate of laboratory rats and causes a significant decrease in food intake, indicating possible effects on enzymes involved in the metabolic processes.

Aroclor 1254 apparently has several modes of action in *Hydra*. PCB affects the mitotic index, feeding behavior, and nervous activity. Although the hydras have a high tolerance to PCB exposure the effects of PCBs are cumulative (over a period of time) and irreversible.

Acknowledgements

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ASPECTS OF ENVIRONMENTAL DISASSOCIATION AMONG THE QUECHUA-SPEAKING POPULATIONS OF RIO NAPO, AMAZONIAN ECUADOR

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ABSTRACT

Quechua-speaking populations of the Río Napo area of Amazonian Ecuador have in recent years been subject to increasing acculturation pressures. This study focuses upon basic environmental adaptations, particularly subsistence activities and dietary habits, as a means of assessing acculturative effects. Progressive dissociation of the indigenous population from the natural habitat emerges as a major feature of this process. The consequent disruption of traditional subsistence patterns raises the prospect of dietary degradation and increased morbidity/mortality rates.

INTRODUCTION

Acculturation, the phenomena resulting from lengthy contact between human populations pursuing different modes of life (Redfield, Linton and Herskovits, 1936), are widely discussed in the literature. Populations, including those of Amazonia, subject to conquest, warfare, forced migration, trade, pacification, missionization, and more recently economic development, exemplify the accumulative processes. Frequently encountered in the literature are the terms cultural disintegration, assimilation, fusion and cultural creativity to convey a direction or trend of changes. However, recent emphasis on ecological analysis in anthropology, integrating biological and cultural perspectives, attracts attention toward basic environmental adaptations of human groups, particularly subsistence activities and dietary habits, and the manner in which acculturation influences these patterns.

From an ecological aspect, acculturation may be viewed as a complex of biological and cultural stresses. One indicator of biological stress, which also may be related to cultural factors, is the disassociation of the indigenous population from the natural habitat. The aforementioned disrupts traditional subsistence practices which subsequently may proceed to dietary degradation, malnutrition, and increased infant and chilld mortality.

Historical Resume

According to Burbano Martinez, Antonio Rivadeneira and Montalvo Montenegro (1965), the Yumbo (lowland Quechua), numbering approximately 33,000, are in acculturation within a particularly favorable ecological situation. Rubio Orbe (1965) noted that the "Yumbo" reside on the lower reaches of Ríos Aguarico, Napo and Pastaza, although de Costales and Costales (1961) remarked that the appellation is absent from early post-Conquest documents. Contemporary "Yumbos" are descendants of Quijos, Archidonas, Canelos, Aviles, Baezas, Yarasunas, Chitos, Tenas, and more recently, Záparos. Many of the formerly diverse populations spoke or speak dialectical variants of lowland Quechua. Although bilingualism persists, the non-Quechua languages are rapidly declining.

Torero (1965, 1972) and Parker (1965, 1972) in Whitten (1978) concluded that "lowland" or "jungle" Quechua is not attributable to the Incan conquest of the Ecuadorian sierra. The origin of lowland Quechua dates from a more ancient linguistic dichotomy. This hypothesis views the expansion of Quechua into the tropical lowlands prior to the incursion of an Incaic variant by several centuries.

de Costales and Costales (1961), Rubio Orbe (1965), and Burbano Martinez, Antonio Rivadeneira, and Montalvo Montenegro (1965) observed that the lowland Quechua and other tribes of Amazonian Ecuador have been subjected in recent decades to intensive, calculated, white-oriented acculturative pressures by missionaries, colonists, and civilian and military authorities. In specific instances, integration into the national culture has occurred (Rubio Orbe, 1965).

Contrarily, Whitten (1976, 1976a, 1978) emphasizes that native Amazonian populations often respond to appropriation of their ecosystems with counter-cultural reactions. Resistance often assumes symbolic or ritual display termed ethnogenesis or surgent ethnicity. Protestations of Amazonian peoples are usually ignored or regarded as primitivistic obstacles to "rational" exploitation of Amazonian resources. In reality, the collective wisdom of the multi-millenial adaptations of Amazonian populations hold greater promise for the preservation of the environment and culture in the tropical forests.

Rubio Orbe (1965) allocated contemporary indigenous populations of Amazonian Ecuador to three cultural levels:

(1) Social organization a clan or simple patriarchy; fields cleared in specific localities; hunting and fishing; either no garments, loincloth, or wraparound; rejection of all foreign objects. No Quechua-speaking groups. Awishiri (Auca).

() Social organization a patriarchy or polygamy; cultivation of yuca, plantain, sweet potato; one-room dwelling circular in outline; weapons and tools obtained from rainforest environment; fetishist; acculturation limited to material elements; environment dominates individual; individuals residing near non-indigenous settlements salaried workers; low level of bilingualism; adoption of national civilian and religious ceremonies. Some lowland Quechua. Most Cofán, Záparo and Jívaro along rivers and in areas not settled by whites.

(3) Direct and permanent contact with whites; material and non-material acculturation; salaried agricultural laborers; some degree of relative autonomy; limited acceptance of introduced plants and animals. Most lowland Quechua. Some Jívaro.

Previous acculturative studies on the Quechua populations of Río Napo in which other acculturative indices were examined are those of Fugler (1969) and Fugler and Ross (1970, 1970a, 1971).

Methodology

The data are extracted from an interview schedule designed to elicit information on agricultural practices, hunting and fishing techniques, health, and sanitation and from extensive field studies.

Interviews with heads-of-households were conducted by a bilingual (Spanish and Quechua) mission-educated male native to Río Napo and the senior author.

Twenty-seven villages, varying from three to at least 120 dwellings, were surveyed. Except for one village on Río Aguarico, all villages (caseríos), comprising 212 family dwellings, are situated on Río Napo and its tributaries (Fig. 1). Responses were obtained from 142 heads-of-households, 67% of the population sample.

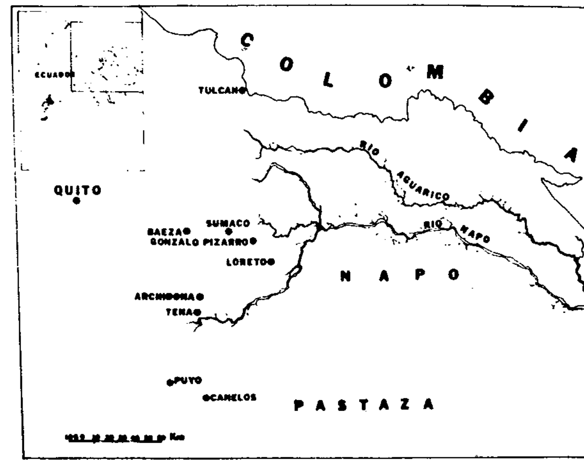

FIG. 1. *The Río Napo and Its Principal Tributaries*

All of the lowland Quechua-speaking villages (*caseríos*) surveyed (27) are located on Río Napo except one (Santa Cecilia) situated on Rio Aguarico. The caseríos of Río Napo (village name, number of dwellings and number censued in parentheses are Achupara (6,4), Ahuano (35,20), Amaron Mesa (10,7), Bella Vista (15-7), Campana (10,10), Capacuy (8,4), Cotococha (7,3), Descano (3,3), Huagra Punta (1,1), Huamayaco (3,3), Huiririma (3,3), Itaya (5,3), Limón Cocha (21,18), Mandi Cocha (5,4), Pando Chicta (5,3), Pompeya (9,5), Primavera (4,4), San Carlos (2,2), San $Carlos_2$ (7,6), Sani Isla (2,1), Santa Rosa (6,6), Samona (5,3), Sinchi Chicta (13,11), Sumino (12,5), Tahua (3,1), Tolima (4,3).

Characteristics of the Villages

High bluffs are the preferred village sites of the riverine Quechua. In larger villages, the soccer fields serve as the village plaza. In mission-dominated villages, the church is the most imposing edifice. Some *caseríos* are less compact; the dwellings are widely dispersed, often located on small islands. In amorphous villages a network of intervening footpaths connect the habitations.

At the immediate rear of the village looms a wall of rainforest perforated by trails leading to the fields (*chacras*) and by well-defined hunting trails. Intrusions of dense forest and *chacras* effectively isolate neighboring houses except for those bordering the central plaza.

Among the villages surveyed, the maximum number of habitations does not exceed 35. The population of the villages may fluctuate widely in that households migrate to fishing or hunting sites or to participate in temporary salaried labor. Dwellings remaining unoccupied are rapidly encroached upon by dense second-growth forest.

The larger villages are associated with missions (Limón Cocha and government posts (Ahuano). The average number of dwellings is 7.5, although in the foothills of the Andean cordillera, where subsistence agriculture is not prerequisite to survival, the village populations are greater.

Elementary schools are operative under the auspices of religious missions and the Ecuadorian government.

Instructors are mission-educated bilingual (Spanish and Quechua) males in the mission schools and monolingual (Spanish) highlanders in the government schools. The level of instruction terminates after the sixth year.

Medical assistance is available in five villages. Paramedical personnel are restricted to the disbursement of patent medicines and the practice of elementary medical aid.

Most *caseríos* include a small store whose owner is a member of the village. A limited diversity of food and clothing is available.

"Capitanes" are active in eight villages only, indicative of disintegrative processes within the indigenous society. The "capitán" is an elected position the primary function of which is to interface with non-indigenous elements. The "capitán" must hold the respect of the villagers, must be fluently bilingual and must be adept in comprehending white society. The "capitán" serves as an intermediary between the villagers and whites in all interethnic intercourse.

An average of 6.4 individuals reside in 142 habitations. The household may include grandparents, persons whose consanguinal relationship to the family could not be established as well as the immediate biological family (P_1 and F_1).

FOOD PLANTS

The slash-burn (swidden) technique is utilized to clear forest plots (*chacras*). Except in two localities in which population density required that plots be cleared at a distance from the village, the *chacras* are invariably situated near the village. The Napo populations maintain two *chacras* as do the Canelos Quechua (Whitten, 1976), the more distant termed *purina* or *miticushca chacra* (hidden plot). Plantain (*Musa paradisiaca*) and yuca (*Manihot dulcis*) are planted at random within the *chacra*. The aforementioned are the preferred domesticates (Table 1).

TABLE 1. *Food Plants Cultivated by the Lowland Quechua*

Cultivate	% of Families
Yuca (*Manihot dulcis*)	89.3
Plantain (*Musa paradisiaca*)	94.0
Yuca and Plantain	4.2
Maiz (*Zea mays*)	5.6
Bean (*Phaseolus*) and Peanut (*Archis hypogaea*	0.7

Number of Families = 142

Yuca, a pre-Conquest domesticate, and plantain, perhaps an early post-Contact introduction, are ubiquitous among the populations of northwestern Amazonia. Gouron (1966) viewed the spread of manioc with apprehension, observing that the tuber is low in proteins, fats and minerals. Leung (1961) determined that the food energy of *Manihot dulcis* is relatively low and that of plantain, lower. Yuca thrives on any tropical soil and accommodates to any rĕgime of tropical rainfall. Under favorable conditions the yield is enormous and under poor conditions, large.

The Napo Quechua are agricultural traditionalists. Although experiencing a lengthy exposure to a diversity of edible plants introduced by white highlanders, a limited number of recent introductions have been accepted by a limited number of families. Traditional attitudes are also expressed by the small percentage of mixed *chacras* of yuca and plantain (Whitten, 1976) maintained on Río Napo. A variety of fruits, jícama, yautía, taro and palms are cultivated in kitchen gardens. Curcubits, papaya and forest sugarcane are frequently grown in the plots.

The inhabitants of northwestern Amazonia traditionally abandon yuca and plantain plots after the second or third season, adhering to the pre-Contact pattern (Table 2) of lesser acculturated tribes. Lowland Quechua in contact with highland colonists acknowledge that plots do not deteriorate with continued use.

TABLE 2. *Cyclical Abandonment of Agricultural Plots (Chacras) Among the Lowland Quechua*

Cultivate	Number of Growing Seasons					
	1	2	3	4	5	6
Manihot dulcis	54.3%	27.3%	8.3%			
Musa paradisiaca	6.2%	40.4%	44.5%	7.8%		0.7%

Carneiro (1968) observed that yields remain at high levels for considerable periods on tropical soils in the absence of fertilizers. If continuous cultivation is prolonged beyond ten years, the primary nutrients (nitrogen, phosphorus, potash) are dissipated. Carneiro concluded that plots are abandoned after the second or third year in that energy expended in weeding an old *chacra* is greater than that required to clear a new plot.

Land pressure, either from whites or indigenes, is not significant in the abandonment or re-utilization of *chacras*. Approximately 94% of the heads-of-household cleared forests when new fields were desired; 93% remarked that virgin land was still available. Negative responses were most frequent in the region of Ahuano into which colonists are settling under government programs.

HUNTING AND FISHING

Hunting and fishing were the primary sources of protein among the riverine population prior to Contact and remain so among lesser acculturated tribes.

Hunting and fishing, environmental exploitation, are dominant activities among the lowland Quechua (Table 3. The frequency of environmental exploitation in pre-Contact times is undocumented nor are data available on lesser acculturated groups in Amazonian Ecuador. Environmental exploitation unquestionably occupied a significant role in the procurement of food. Dietary degradation ensued with a decrease in hunting and fishing, cardinal activities in maintaining harmonious ecological relationships. Energy is displaced into salaried activities.

TABLE 3. *Hunting Activity Among the Lowland Quechua*

Time Sequence	Hunting Activity: Yes	Hunting Activity: No	Number of Male Respondents
Day 1	15.3%	84.7%	138
Day 2	30.1%	69.9%	136
Day 3	30.9%	69.1%	139
Day 7-14	41.1%	58.9%	139

The weapons and techniques employed in faunal exploitation are indicative of acculturative pressures; shotguns are possessed by 36% of the heads-of-household; chimeneas (front-loading section of lead pipe insecurely attached to hand-carved wooden stock), 57.9%; blowguns (*pucuna*), 1.7%; lances, 1.7%. Although the abundance of firearms would ordinarily indicate greater proficiency, in fact, it is greatly reduced. Ammunition is costly and difficult to obtain. The manufacture of blowguns is limited to a few individuals among whom the blowgun and lance are the exclusive hunting implements.

Only 2.9% of the heads-of-household concoct "curare" for which 40 or more species of plants are utilized. Approximately 4.0% of those involved in hunting possessed "curare" pots. The Río Napo Quechua ceased the manufacture of dart poison as it became available from Peruvian sources through established trade routes. The locally prepared "curare" is less potent than the Peruvian. The adjacent tribes (Cofán, Secoya, Awishiri, Siona and some Shuar), in infrequent contact with non-indigenes, rely upon traditional implements and more potent poison. The riverine Quechua, apparently having lost the technology of blowgun manufacture, purchase the *"pucuna"* from Shuar traders.

Significant emphasis is placed upon fishing in the total energetics of environmental displacement. In contrast to hunting, pre-Contact means of fishing survive. Handwoven nets of palm fiber (*chambira*) were utilized by 85% of the men. Women neither hunt nor fish. Hooks carved from bone or wood or fashioned from metal were utilized by 4.9%. Fish poisons derived from *Clibadium* spp. and *Longchocarpus* spp. (*barbasco*) were employed by 12.0%. Untended clumps of *barbasco* were infrequently noted in kitchen gardens. Dynamite (*tacos*) was preferred by 54% and battery-powered headlights by 1.4%, but these are virtually unobtainable. The Canelos Quechua fish with spears, traps, weirs, lines and blowguns (Whitten, 1976). The Kalapalo of Central Brazil, less accultured than the Ecuadorian tribes, employ hook and line indirectly introduced by whites (Basso, 1973). Fishing, the most important subsistence activity away from the village, provides the greatest amount of protein in the diet. Meggers (1978) emphasized that a balanced diet is achieved by combining cultivated staples, wild fruit, nuts, game and fish.

TABLE 4. *Fishing Activity Among the Lowland Quechua*

Time Sequence	Fishing Activity: Yes	Fishing Activity: No	Number of Male Respondents
Day 1	4.2%	95.8%	120
Day 2	29.2%	70.8%	137
Day 3	33.9%	66.1%	136
Day 7-14	39.8%	60.2%	136

Food Consumption

The number of meals consumed daily varied from one (8%), two (43%), three (41%) to four (less than 1%). In that lesser acculturated tribes characteristically eat twice daily, extra-tribal influences are indicated.

The nutritive value of the dietary elements varies greatly. The adjacent, lesser acculturated tribes, characteristically consume plantain, yuca, game, nuts and fruits. The fruits and nuts of certain wild plants possess an abnormally high nutritional concentration (Meggers, 1971). Although the diet of the pre-Contact populations on Río Napo is undocumented, it was unquestionably similar to the diet of the adjacent populations which has changed little since that event. The dietary substitutes, of which rice predominates, are nutritively inferior. Other introduced articles include tinned sardines and tuna, sugar, onions, corn, powdered milk, potatoes, noodles, flour, lard, eggs, barley, and occasionally beef. The non-native elements are primarily carbohydrates and liquids (Table 5).

TABLE 5. *Edible Articles Purchased by the Lowland Quechua*

Article	Approximate Time of Purchase: Last Week N=48	Last Month N=64	Usually Purchased N=17
Rice	35.4%	26.7%	41.8%
Sugar	2.0%	1.5%	11.7%
Potato	6.7%	6.2%	5.8%
Yuca	2.0%	1.5%	5.8%
Plantain	2.0%	1.5%	5.8%
Flour (Wheat)	2.0%	0.0%	0.0%
Beans	2.0%	0.0%	0.0%
Meat	2.0%	7.8%	5.8%
Milk (Powdered)	2.0%	1.5%	0.0%
Tuna (Tinned)	22.8%	25.4%	0.0%
Sardine (Tinned)	17.0%	10.9%	0.0%
Onion	4.1%	7.8%	5.8%
Noodle (Flour)	0.0%	3.1%	5.8%
Lard	0.0%	3.1%	11.7%
Chicken	0.0%	1.5%	0.0%
Egg	0.0%	1.5%	0.0%

The figures represent the percentage of total articles purchased during each time interval.

Although consumed only on festive occasions and therefore of little nutritional significance, domesticated animals serve as a source of money and barter (Table 6). Cattle are recent introductions to the Río Napo Quechua. Except for the dog, all domesticated animals are of post-contact origin.

TABLE 6. *Ownership of Domesticated Animals Among the Lowland Quechua*

Variety	Percent of Male Respondents
Chicken	42.3
Swine	17.3
Cattle	6.4
Duck	5.5
Dog*	28.2
None	0.3

N = 138 * Not a source of food

Conclusions

Centuries of adaptation to the ecosystem of the tropical rainforest by the indigenous populations of the lowlands has resulted in a harmonious existence with the environment. Within recent years the Amerindian populations of Río Napo have been subjected to increasing pressures from external sources. These acculturative stresses have markedly changed the relationship of the indigenous populations to their ecosystem.

Traditional techniques of environmental exploitation are being supplanted as elements of the population seek salaried work. Correlatively, the quality of the diet deteriorates as carbohydrate consumption increases and protein consumption decreases. The introduction of domesticated animals, potentially utilizable as a significant source of protein, constitutes a source of money and exchange only.

The data suggest that the riverine populations are disassociating from the environment as a result of decreased hunting and fishing, increased reliance on tinned and processed foods and the trend towards a cash economy. Certain aspects of biological and cultural stress are identifiable: dietary degradation and a reordering of priorities.

Cohen (1968) emphasized that "A population's adaptation is its relationship to its habitat. The adaptation of man is accomplished principally by cultural means, through the harnessing of new sources of energy for productive ends, and through the organization of social relations that make it possible to use these energy systems effectively. Whenever groups of people introduce a new source of energy into a habitat they create a new environment.

Acculturation among the indigenous populations of Río Napo is evidenced by the stage, however transitory, in which the population is in environmental disassociation. The introduction of new stress factors through acculturation hinders the process through which the population adapts to the environment. Cohen (1968) states that adaptation implies "the processes by which a population or group alters its relationship to the habitat." The negative consequences are a failure to accommodate to the environment and therefore are maladaptive. We conclude that the cultural decline of the indigenous populations are maladaptive and perhaps irreversible.

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