Human Ecology, Vol. 7, No. 3, 1979

A Comparison of the Efficiencies of the Shotgun and the Bow in Neotropical Forest Hunting[1]

Raymond B. Hames[2]

Whenever introduced into Amazonia and its neighboring regions, the shotgun has quickly replaced the bow and arrow and other aboriginal weapons of the hunt. The quick and widespread adoption of the shotgun is plainly a matter of its superiority over most aboriginal weapons. This paper compares the hunting efficiencies of the shotgun and the bow by means of a controlled field experiment among the Ye'kwana and Yanomamö Indians of the Upper Orinoco River of southern Venezuela. It also examines the impact of the shotgun on local animal populations and the economic changes brought about by the need to cash-crop in order to purchase Western hunting technology.

KEY WORDS: neotropical forest hunting; technology; culture change; neotropical forest ecology.

INTRODUCTION

The introduction of a new technology to a primitive society has a profound effect on its economy, social organization, and relation to the environment. Most detailed studies of this phenomenon have dealt with the transition from stone to steel axes, especially in relation to increased efficiency in forest clearing for garden making. All of these works (Salisbury, 1962; Erasmus, 1965; Townsend, 1969; Saraydar and Shimada, 1971, 1973; Cranstone, 1972) point out that steel axes are 300 to 600% more efficient than stone axes in time expenditure and 300 to 500% more efficient (Saraydar and Shimada, 1971, 1973) in terms of

[1]Funds for the research and writing of this paper were made possible by an NIMH predoctoral fellowship to Napoleon A. Chagnon, Grant No. NIMH 5 R01 MH 26008-SSR.
[2]Department of Anthropology, University of California, Santa Barbara, California.

caloric expenditure. The major impact of steel axes on neolithic economies is to lower subsistence effort and increase leisure time (Salisbury, 1962; Sharp, 1969). Furthermore, the works of Salisbury (1962) and Sharp (1969) have shown that the introduction of steel axes has had profound and rather surprising effects on aspects of socioeconomic organization, such as disruption of aboriginal trade relations, breakdown of status hierarchies, increased dependence on colonial powers, and dissolution of cultural values.

In contrast, little systematic study has been done on hunting technology replacement, specifically the introduction of firearms. Perhaps the most detailed work on the subject is Sonnefeld's study (1960; cf. also Kemp, 1974: 365) of the introduction of firearms into traditional Eskimo hunting economy. Through a careful analysis he was able to show that although firearms were generally superior in bringing down more game (e.g., caribou, birds, and seals), they were not superior in every instance. The main exception was *maupok* sealing; the traditional harpoon was more effective because once hit, the seals could be successfully retrieved by a line attached to the harpoon, whereas if shot with a rifle, approximately 9 out of 10 were able to escape through breathing holes into the water (in spite of being mortally wounded in many cases). He concluded that the main socioeconomic effects on Eskimo life were greater hunting effectiveness, a reduction in cooperative hunting, and a loss of technological and economic autonomy through an increasing dependence on unstable Canadian trading networks.

Wherever introduced in native South America, the shotgun, and in some cases the rifle, has quickly replaced the bow and arrow, the blowgun, and the lance, the most important traditional Indian hunting implements. As early as the middle of the 18th century, Indians of the Guyanas traveled to Georgetown and Angoustora (today, Ciudad Bolivar) to trade with the British and Dutch to acquire arquebuses and muskets, a pattern manifested in most other parts of South America (cf. Harner, 1968a for an account of the Peruvian-Ecuadorian area). Today shotguns or rifles are found in most contacted villages and it is increasingly difficult to encounter Indian communities still completely reliant on traditional hunting implements. The obvious reason for its widespread acceptance, which is echoed in most ethnographic accounts that touch on the subject, is simply that the shotgun is greatly superior to indigenous implements for killing game. In his account of Amazonian Mundurucú Indians, Murphy (1960: 55) cogently explains why this is so:

> The increased use of firearms is highly significant in this regard. Even a ball from a muzzle-loading shotgun has a greater range and velocity than an arrow. The lower power of the arrow is especially noticeable at longer distances, for its large surface area causes it to be considerably slowed by air friction. Besides, the bullet has greater stopping power. This is important, for the wild pig and tapir frequently run for hours with two or three arrows in their bodies. In the village of Cabrua, the men owning firearms frequently hunted alone while those using bows and arrows depended on their companions for added firepower and the opportunity to mount ambushes from which the animals could be shot at close range.

Most anthropologists who have studied hunting in tropical America implicitly agree with the above statement (e.g., Gillin, 1936; Holmberg, 1954; Siskind, 1970; Nietschmann, 1973, 1978; Lizot, personal communication; Beckerman, 1978; Good, 1978). However, in his recent attempt to explain Amazonian food taboos, Ross (1978) maintained that traditional neotropical hunting technology (i.e., the Achuara Jívaro bow and arrow) is superior to the shotgun in killing several kinds of game. He notes, "It is clear that shotguns have reduced the efficiency with which certain important animals – in particular, the terrestrial quadrupeds [i.e., deer, capybara, and tapir][3] – can be killed" (Ross, 1978: 12), and "Monkeys have presented a different kind of problem; they are frequently beyond the effective range of the shotgun, and it is not uncommon for two or three animals to escape for every one that is eventually caught." Ross stands nearly alone in this belief. He cites no comparative rates of killing efficiencies for either weapon, and bases his claims on the qualitative assessments of others and, presumably, those of his own field experience among the Jívaro. Furthermore, he ignores the observations of other neotropical ethnographers who have arrived at precisely the opposite conclusion. Three reviewers of Ross's article (Beckerman, 1978; Good, 1978; Nietschmann, 1978), all of whom have recently studied hunting in tropical America, disagree with his position. Nevertheless, in his reply to them, Ross (1978: 30) maintains, "I do not, incidentally, say that shotguns can never kill large game, but that these species are hard to kill and apparently more easily killed by traditional specialized arrows" (Ross, 1978: 30).

The primary aim of this paper is to present the results of a controlled comparison of the efficiencies of the shotgun and the bow and arrow in neotropical forest hunting among the Ye'kwana and Yanomamö Indians of Amazonas Venezuela. A second aim is to assess the socioeconomic consequences of the introduction of the shotgun on hunting technology and the impact of the shotgun on local animal populations.

THE SETTING

Research among the Ye'kwana and Yanomamö Indians took place between March 1975 and June 1976. The Ye'kwana village of Toki was chosen because it contained a resident population of Yanomamö, thereby permitting a study of intercultural relations and a comparison of different economic adaptations to an identical environment. The Padamo River Basin where Toki is located

[3]According to Ross, the main impetus for the Achuara Jívaro to trade for shotguns was to attain technological parity with other Jívaroan groups who were effectively using shotguns in warfare. It is odd that Ross says a shotgun is *more* effective against humans who are larger (50-60 kg) than the capybara (40 kg) or the various species of the deer genus *Mazama* (30-45 kg).

is a border area separating the easternmost extent of the Ye'kwana population and the westernmost Yąnomamö population. The village contains 76 Ye'kwana, 35 Yąnomamö (half of whom live within the village in a single dwelling with the other half living in another dwelling 15 minutes downstream from Toki) and an additional 16 Yąnomamö who live in Ye'kwana houses, largely as a result of intermarriage. Relations between the Ye'kwana and Yanomamö have not always been as peaceful as they are today. Warfare between the two societies has been reported as far back as 1837 (Schomburgk, 1840). In the late 1930s several Ye'kwana villages in the headwaters of the Caura, Ventuari, and Padamo rivers banded together, purchased shotguns, and destroyed a number of Yąnomamö villages that had been raiding them for years. Since that time relations have been peaceful and a number of Yąnomamö villages, particularly in the Padamo, have joined Ye'kwana villages or moved nearby in order to take advantage of Ye'kwana trade goods by purchasing them with labor or goods of their own manufacture. Except for strictly economic exchanges, little interaction occurs between the Ye'kwana and the Yąnomamö of Toki; for the most part the two cultures are socially and economically independent of each other.

YE'KWANA AND YĄNOMAMÖ HUNTING TECHNOLOGY

The Ye'kwana and Yąnomamö have a large number of weapons at their disposal with which they kill animals of the hunt. Aside from shotguns and bows, which are primarily all-purpose weapons, they employ a number of secondary and specialized weapons such as blowguns, machetes, lances, dogs, smoke, axes, makeshift clubs, traps, and even their bare hands.[4] Before the advent of the shotgun, the blowgun was the primary Yekwana hunting weapon. Today it is used only by boys to hunt birds that abound in the secondary forest surrounding Toki. Formerly the darts were tipped with a very potent kind of curare obtained in trade from the neighboring Piaroa Indians. Curiously, some Yąnomamö of the Upper Orinoco have shown an interest in the blowgun, and the Ye'kwana trade a small number to them each year. In pre-shotgun days some Ye'kwana also hunted with a bow, which was much smaller than the Yąnomamö bow. Upon contact with the expanding Yąnomamö population in the 19th century the Ye'kwana began to trade for the Yąnomamö bow, giving up their own. Today, they are able to fabricate the bow as expertly as the Yąnomamö.

Lances are used by both societies mainly for hunting white-lipped peccaries and by the Ye'kwana alone for killing game which has been flushed into a river toward lancers waiting in canoes. Tridents are used by the Ye'kwana solely for

[4] The forest tortoise *(Testudo sclupta)* is always taken by hand. Also, two fawns were caught by hand and strangled during my fieldwork.

hunting caimans from canoes. The remaining weapons are used when: (1) an animal is wounded, (2) an animal is hidden in a hole or the bole of a tree, (3) a kill can be confidently made without the use of a primary weapon, or (4) when one is low on ammunition. Nevertheless, 91% of all Ye'kwana kills and 94% of all Yąnomamö kills were made with the shotgun and bow, respectively. Below is a description of the technical qualities of the shotgun and bow in relation to hunting.

Shotgun

In the late 1950s and the early 1960s the Ye'kwana of Toki began to receive a steady supply of shotguns and ammunition from missionaries, criollo traders, and government agents (predominantly members of the Comisión de Límites, who employed Ye'kwana to map border areas). According to historical sources (Civrieux, 1970) the Ye'kwana first obtained muskets and arquebuses at Angoustora and Georgetown from the Dutch and British in their wide-ranging trading expeditions. The supply sharply increased in the late 1930s when the Ye'kwana acquired a large number of shotguns in order to defeat a group of Yąnomamö in several allied villages, who had been raiding them for years. But only for the last 10 years have all members of the village had shotguns and a more or less reliable supply of ammunition. Therefore, most men over 25 years of age grew up using the blowgun or bow in hunting. In contrast, none of the Yąnomamö of Toki, except for those who live in Ye'kwana households, own shotguns; moreover, they are rarely able to borrow them from the Ye'kwana. In fact, only four or five shotguns are owned in the other seven Yąnomamö villages of the lower Padamo.

The shotguns are typically 16-gauge, breech-loading, single shot, and full choke. One Ye'kwana owns a 22-caliber rifle and 16-gauge double barrel shotgun, while another owns a 20-gauge shotgun. The guns are generally such North American and Canadian makes as Winchester, Remington, and Savage; only a few are made in Brazil. Most are at least second or third hand and are rusted and worn, with faulty ejectors and triggers. Nevertheless, the Ye'kwana take good care of their weapons, which is difficult in a humid and rainy climate with a lack of cleaning kits, and they are adept at repairing worn ejectors and firing pins with pieces of scrap steel.

Cartridges, shot, powder, and primers are obtained from missionaries or are purchased in small Venezuelan towns three or four day's journey on the Orinoco River from Toki. Cartridges are used as many times as possible. Since cardboard cartridges tend to swell and deteriorate due to the constantly high humidity, plastic cartridges are much preferred. When cartridges swell so much that they cannot fit the chamber, they are left out in the sun to shrink.

The smallest shot used, and the most common load by far, is #4 shot. This all-purpose shot is heavy enough to kill medium-sized terrestrial animals such as pacas and peccaries, and has a pattern broad enough to hit flying birds. Heavier shot, such as double-aught (buckshot) or rifled slugs, is also carried by hunters for tapirs, deer, and capybaras. Although the Ye'kwana prefer white powder since it is much more powerful, they are rarely able to purchase it, and must rely mainly on black powder. The Ye'kwana never purchase wadding: instead, they make their own from bark shavings of one of several species of palm (*Euterpe olearcea* and *Jessenia* sp.). Cultivated unspun cotton is employed to cap the top of cartridges to prevent the shot from spilling out.

When reloading cartridges, the Ye'kwana use about two-thirds to three-quarters of the standard amount of powder and shot (according to the measuring cups in my shotgun cartridge reloading kit). Whenever I used a reloaded Ye'kwana cartridge, I found that it had little "kick," but the shot seemed to have normal range. When I asked why they used so little powder and shot, I was told that they were afraid of exploding the breech and, besides, enough was put in to kill whatever was being hunted. This conservative practice is understandable in relation to the scarcity and high prices (relatively and absolutely) of cartridge components and the poor conditions of most shotguns.

Bow and Arrow

The Yąnomamö bow and arrow is the common self bow (or simple bow) of the D type (cf. Hamilton, 1972, for a classification of bows) used by nearly all New World tropical forest peoples. The bow is from 1.9 to 2.2 m long and 5 to 8 cm in circumference. It is made from one solid piece of wood from one of two species of palm, *Guiliema gasipaes* (or peach palm) or *Jessenia policarpa*, with the former greatly preferred. The stave is slightly ovoid in cross section and it tapers gently to a circumference of 0.8 cm at each nock. Arrow shafts are about 2.2 m long, 1.8 cm in circumference, and weigh 70 to 77 g. The shafts are made from the hollow flowering stem of the cultivated arrowcane plant, *Gynerium sagittatum.* The fletching is composed of two feathers which are slightly bent along the axis of the shaft so the arrow will spin in flight. The feathers are taken only from members of the *Cracidae* family, especially the crested or helmeted currasow. Finally, the bowstring is made from the cultivated bromeliad, *Annas carmargo paraguasense,* or bast from the trumpet wood, *Cecropia metensis.*

There are three basic types of arrow points. A broad but thin lanceolate point is carved from a species of bamboo (*Guasdua latifolia*) and is used against large game. It is 10-15 cm long and 2-2.5 cm wide at its widest point. It is attached to the arrow by inserting it into the hole at the top of the shaft. about 2 cm deep, and then tightly binding the outside of the shaft with cotton thread. Binding in this way prevents the point from being forced further into the shaft when something hard is struck, and splitting the shaft. The harpoon point, which is used to kill birds and small terrestrial game, is fashioned by attaching a foreshaft,

made from a hardwood bush (*Sorocea guyanensis*), into the main shaft's cavity and then attaching a thin, slightly curved piece of monkey fibula to the end of the foreshaft. One end of the fibula serves as the penetrating point while the other end becomes a barb. This bone point is attached to the foreshaft with cotton thread coated with the latex of the balata tree (*Mimusops bidentada*). Also, the arrow shaft for this point is slightly shorter and narrower than those used for other points. A poisoned arrow point is used against monkeys and sloths (and occasionally against humans). It is made from a narrow palm sliver 12-15 cm long which is coated with curare.[5] This point is notched around its circumference about every centimeter so that when it strikes an animal it will break off inside, allowing the poison to work. The point is particularly effective against sloths and monkeys because if these animals are shot with a shotgun or with a different arrow point, they will remain suspended in a tree even while dead; however, since curare is a powerful muscle relaxant, with a poisoned point the animals fall to the ground in 5 to 10 minutes. Finally, the Yąnomamö occasionally fabricate a multipronged point that is used to stun birds. It is usually made on the spot while hunting, and is simply a bush that has been cut where several branches diverge from a main stem.

While hunting, a Yąnomamö commonly carries three arrows armed with the three main types of points. Around his neck he suspends a bamboo quiver filled with a dozen or more spare arrow points, thread, latex, and agouti-tooth tools. Since nearly every time an arrow is fired, at least the point is damaged, an archer uses this tool kit and spare parts to sharpen dull points, replace broken points, or repair broken arrow shafts.

Before going on with a technical comparison of the shotgun and the bow, it would be instructive to note the comments made by Pope (1923) and Hamilton (1972) on a bow very similar to the one used by the Yąnomamö. Despite its ubiquity in the New and Old World tropics it has a number of drawbacks when compared to bows and arrows used by native hunters in other parts of the world. According to Hamilton, the most efficient bows have a bow-length : draw ratio[6] of 2.2:1, but the bow : draw ratio of the Yąnomamö bow is about 3.3:1. Although quite strong, the palm wood used in bow manufacture recoils sluggishly and unevenly, factors which Pope regards as critical for evaluating bow effectiveness. Hamilton points out that an arrow of only 1.25 oz (35 g) is capable of killing any North American animal, yet Yąnomamö arrows weigh 70-77 g. Finally, of the 33 bows tested by Pope for the ability to cast arrows, the type of bow used by the Yąnomamö ranked 32nd, at 90 m. An immediate question

[5] Yąnomamö curare is made from *Strychnos peckii* and *Strychnos* sp. For a detailed description of its preparation, see Lizot (1972).

[6] "... the actual distance the arrow is pulled back in the bow measured from the front of the grip" (Hamilton, 1972: 26).

arises: If the self D bow is so poor in comparison to other bows around the world, why is it so common in tropical forest environments? A possible answer to this question is given by Evans and Meggers in a personal communication to Hamilton's monograph. From their observations of the Waiwai of British Guiana, they note that large and heavy arrows are less likely to be deflected by dense tropical vegetation. Indeed, this is one of the reasons that the Ye'kwana gave to me for their adoption of the larger Yąnomamö bow. They also added that the Yąnomamö arrow hits animals harder because it is heavier. Therefore, a long and heavy arrow shot with a sluggish bow at animals at close range in a dense forest may be a most efficient weapon.

TECHNICAL COMPARISON OF THE SHOTGUN, THE BOW, AND THE BLOWGUN

Below, the bow, the shotgun, and the blowgun are compared in relation to a number of variables that are crucial in evaluating their performance in killing game. The variables are range, force of impact, maneuverability, and obtrusiveness. Even though thus far I have not commented extensively on the blowgun, and do not compare its hunting efficiency to the bow and the shotgun, I include it in this section because second to the bow, it is the most commonly used Amazonian hunting implement.

In order to compare the ranges of the shotgun, the bow, and the blowgun, I assembled a group of the best Ye'kwana and Yąnomamö hunters and asked them to participate in an experiment. I instructed a boy to move away from the group carrying a tape-measure and requested the hunters to tell him to stop when he reached the maximum distance for killing large birds and monkeys and large terrestriads with the shotgun, bow, and blowgun. The results are listed in Table I.

Before proceeding with further comparison, it must be noted that the maximum effective range for each weapon is seldom realized while hunting due to dense forest vegetation. Generally, it is difficult to get off a clear shot, regardless of the weapon, beyond 15-20 m.

The range of the blowgun remains the same for birds and terrestrial animals since all that is required of the needle-sharp dart is that it pierce the animal's flesh. However, the ranges for the shotgun and the bow change significantly according to the animal: the range of the shotgun for large game is 58% of its range for birds and monkeys while the range of the bow for large game is 82% of that for small game. Overall, the shotgun has an 18 m advantage over the bow for birds but only a 4 m advantage for large terrestrial animals. Since the shotgun is basically a fowling piece, it is no surprise that its range for birds is much greater than that of the bow. The enormous spread of pellets makes arboreal animals easy targets, since just one pellet of the smallest shot

Table I. Maximum Distance for Killing Large Birds and Monkeys and Large Terrestriads with the Shotgun, the Bow, and the Blowgun

Weapon	Large birds and monkeys	Large terrestriads
Blowgun[a]	17 m	17 m
Arrow[b]	25 m	21 m
Shotgun	43 m	25 m[c]

[a] Stirling (1938) claims that the maximum range for the Jivaro blowgun is 42 yards (38.4 m). In addition, he says the length of the blowgun determines the range of the dart; some Jívaro blowguns are 4.6 m long while the Ye'kwana's are only between 3 and 3.7 m. For the Ye'kwana, Barandiaran (1962) notes the range is between 20 and 50 m; and Harner (1968a) and Vickers (1976) say the range of the Jívaro and Siona-Secoya blowguns are 31 and 25 m respectively. Although these estimates are greater than my experimental results, I am concerned with maximum effective range, i.e., the greatest distance at which one will risk taking a shot.

[b] Holmberg (1950) writes that the maximum effective shooting range for the Siriono bow, which is nearly identical to the Yąnomamö bow, is 28 m.

[c] With a rifled slug, the range for large terrestriads is 37 m.

used (#4) is often sufficient to kill a bird. The greater range decrease from birds to large terrestrial animals is probably due to the same factor: at distances the short pattern is so diffuse that too few pellets strike the animal to bring it down. It is difficult to explain why the range of an arrow does not change greatly between large and small animals, but perhaps it is because an arrow is a large and unitary projectile and its force of impact over distance is more constant.

At short range the impact of a shotgun blast is much greater than that of an arrow. A lanceolate bamboo arrow point cannot penetrate bone, except, perhaps, at point-blank range. If a large animal is hit in the skull, ribs, hips, or any other bone near the surface of the skin, the arrow will shatter, glance off, or be shaken loose by the animal which will flee with only a slight wound. But the impact of buckshot (double-aught) or rifled slugs is devastating to any animal. These loads can easily shatter the skull of a white-lipped peccary or a tapir at a range of 35 m or more.[7] For birds, the impact of a harpoon arrow is probably greater than that of shotgun pellets due to its heavier weight.

[7] The deadliness of even the smallest shot (#4) used by the Ye'kwana against the largest South American animal was made clear to me in the field. Julio, the headman of Toki, flushed a young tapir (173 kg) into the Padamo River where Enrique and I were waiting in a canoe. We paddled the canoe to within about 9 m of the swimming tapir and Enrique hit it squarely in the neck. The animal immediately sank, mortally wounded, and we recovered it an hour later when it resurfaced.

There are subtle differences between weapons which importantly affect hunting success. When hunting with a bow, a Yąnomamö or Ye'kwana can carry a maximum of only four arrows and their great length makes it difficult to maneuver through the forest. Shotguns are much more maneuverable and one can carry as many cartridges as he owns. The blowgun falls somewhere between, for it is as unwieldy as the bow but as many as 50 darts may be carried in a quiver. Carrying a large number of projectiles is important when hunting coveted game such as peccaries and monkeys which tend to travel in large bands. A bow hunter is limited to a maximum of four shots at such game.

Because darts and arrows are essentially silent, they are much less obtrusive than a noisy shotgun. With darts or arrows one may pick off several animals without frightening the rest or have the opportunity to shoot again if he should miss the first time. Again, this is important when hunting monkeys or birds which tend to aggregate in fruiting trees.[8] The blast of a shotgun will usually scatter most animals within earshot, which is one of the reasons why the Ye'kwana hunt small game only when they have failed to find traces of large game: they do not want to scare large game with the report of their guns.[9]

Finally, shotguns are superior in hitting animals on the move and striking them through dense undergrowth. When aiming at a moving target, the slower the projectile, the more difficult the target becomes to hit. According to Dalrymple (1973: 195), the pellets from a 16-gauge shotgun travel 1000 feet (353 m) per second while a modern arrow travels only between 124 and 183 feet (45-66 m) per second. Projectile speed is important for stationary targets as well. Taylor (1956) notes that a deer can jump at the sound of a bow string, thereby dodging the arrow.[10] A bow hunter will not even try to shoot at a moving bird or monkey with an arrow because there is very little chance of hitting the animal and a great chance of losing the arrow. For example, the snowy egret (*Ardea cocoi*) is a riverine bird difficult to approach as a stationary target. However, the birds tend to fly towards the hunter when startled, allowing them to be shot on the wing. During my study, 23 were killed with shotguns but none with bows and arrows. Dense brush, lianas, and branches easily deflect the path of an arrow or dart so much that they will not be risked unless the hunter is sure of a clear shot. As a consequence, the animal may escape as the hunter tries to position himself for a better shot. With a shotgun, a hunter often takes the risk of having a few of his pellets deflected by obstructions, knowing that some are likely to reach their target.

[8] Butt-Colson (1973) describes how a team of two Akawaio hunters picked off an entire flock of birds roosting in a tree using blowguns.

[9] It is difficult to know just how much a shotgun blast alerts animals. Along the river a blast can be heard distinctly, but faintly, for about 2 km. Inside the forest it is difficult to detect a blast more than a kilometer distant due to the muffling effects of dense vegetation.

[10] The Yąnomamö explained to me that one of the reasons why a shotgun is superior to a bow in warfare (aside from its superior killing power) is that one can dodge an arrow but never a shotgun blast. Yąnomamö children participate in mock arrow fights (with blunted arrows) which have the primary aim of teaching them to dodge arrows in flight.

METHODS

In order to compare the efficiencies of the shotgun and the bow as hunting weapons, two major sources of data are required. First, one must sample the total amount of game taken by Ye'kwana and Yąnomamö hunters and record how the game was taken. Second, the amount of time spent hunting must be calculated for each hunter. By combining these two sets of data as a ratio of output to input (kilograms of game per hour of hunting) the comparative efficiencies of each weapon can be evaluated. However, in order to make an accurate and meaningful comparison, all variables which could theoretically influence hunting efficiency must be controlled. Following is a description of the methods used to collect the data, the controls inherent in the field situation, and those which had to be statistically manipulated.

Collecting data on hunting production, or output, was quite simple and enjoyable. Once or twice daily I made a circuit through the Ye'kwana and Yąnomamö sections of the village of Toki and then through the Yąnomamö village of Toropo-teri, stopping at each hearth and inquiring if any game had been brought in that day. Sampling usually occurred late in the afternoon when hunters most often return home. If a hunter made a kill, I noted the following information: (1) hunter's name, (2) date of kill, (3) species and weight of animal, (4) hunting method (bow, shotgun, club, etc.), and (5) location of kill. Any errors in sampling were probably in the direction of underestimation (especially for the Ye'kwana) because occasionally when I would make an inquiry, such as when I would see a woman gutting a currasow outside of the house, I would be told by the hunter disgustedly that he had killed nothing. I soon found out that "nothing" often meant that only a few birds or small monkeys were taken. "Something," on the other hand, meant the killing of an animal the size of a paca (8.5 kg) or larger. Ye'kwana and Yąnomamö hunters enjoy talking about successful hunting, vividly describing the details of the chase, often giving me more information than I wished. The only times hunters were reticent in giving information was immediately after they returned from the hunt. After a successful hunt, both Ye'kwana and Yąnomamö hunters immediately go to their hammocks and, with little conversation, tobacco and/or food is given to them by their wives. Members of both societies consider it inappropriate to speak to a hunter on such occasions; accordingly, I learned to return later to get the information I needed. Once they were habituated to my constant queries and realized my scientific interest,[11] sampling became quite easy. Children would often run to my house to say that so-and-so had just

[11] In the beginning the Indians thought my interest stemmed from a desire to receive a portion of the kill. At first I had to impolitely refuse offers of meat at such times to demonstrate that my interest was purely academic. They quickly got the point and I was later able to accept gifts of meat without seeming to be begging. And whenever I killed a large animal, I distributed it according to customary rules.

killed an animal and that I had better hurry with my scales so that I could weigh the animal before it was fully butchered and distributed to the village.

Data on hunting input were obtained through the behavioral observation technique called instantaneous scan sampling, a method widely used by primatologists (cf. Altmann, 1974; Dunbar, 1975) and used to some extent in child ethological studies (e.g., Draper, 1977). Apparently the method was first devised and used in ethnographic research by Erasmus (1955) in his study of time allocation in a Mayo village, but it received little attention. My own decision to use this method came from reading Johnson's description (1975) of it and then personally discussing with him its strengths and weaknesses.

The method consists of making random observations of the activities of individuals at predetermined times of the day. When an individual is encountered, his or her behavior is noted at the moment of observation. After a sufficiently large number of observations are made through the course of a year, time budgets can be calculated. For example, if an individual is observed a total of 300 times, of which he was observed to hunt 30 times, then one would calculate that 10% of that individual's time was spent hunting. Furthermore, if one knows that, on the average, all members of a population rise at 6:00 a.m. and go to bed at 8:00 p.m. (or are awake 840 minutes per day), then it is a simple matter to calculate the average number of minutes per day spent hunting (or on any other activity or interest) by multiplying the fraction of time spent hunting (10%) by the total minutes per day (840). Using this method, one could say that a particular hunter spent an average of 84 minutes per day hunting.

The other relevant hunting input behavioral variables are method and location. Hunting methods were distinguished as to whether a shotgun or a bow was used and whether the hunt was a day hunt, an expedition hunt (i.e., hunting which extended over a period of at least two continuous days), or any combination. Night hunting, practiced only by the Ye'kwana, had to be sampled differently, since its occurrence fell outside the scan sampling time limits. It was sampled by participating in a number of night hunts, recording the amount of time spent in each, and recording all instances of night hunting by Ye'kwana hunters. By knowing the average duration and the frequency of night hunts for each individual, time budgets could be calculated for this activity. The location variable was used to record the area in which hunting occurred. Most hunting was done along named and well known trails, but some hunting was done near the village or in gardens when fresh tracks were encountered. All trails were visited at least once and the following data were recorded: (1) distance from the village, (2) travel time, (3) approximate size, (4) length of time hunted in years, and (5) environmental features such as topography, hydrography, and dominant plant associations. The relevance of locational data to the comparison of shotgun and bow efficiencies is described below.

The data on hunting input and output were collected simultaneously over a period of 216 days, divided into three segments of 76, 62, and 78 days from July 1975 to June 1976. These sampling periods were designed to correspond to seasonal fluctuations in rainfall which greatly affect hunting. Using instantaneous scan sampling a total of 4,759 behavioral observations were made on full-time Ye'kwana hunters and 3,257 observations were made on full-time Yanomamö hunters.

As in all anthropological field experiments, control is difficult to achieve because of the character of natural human situations. The main element of control shared by both Ye'kwana and Yanomamö hunters is an identical environment. If each group of hunters lived in separate villages some distance from each other, one might argue that variations in hunting productivity are at least partially explicable in terms of game abundance in each area, as related to ecological factors or different histories of exploitation. Fortunately, this problem is overcome in the composite Ye'kwana-Yanomamö settlement of Toki. Nevertheless, there are a number of controls that must be statistically manipulated in order to make an accurate comparison. First, and most importantly, all Ye'kwana night hunting must be excluded, even though night hunting is the most productive hunting method (Hames, 1978), because the Yanomamö never hunt at night.[12] Also, there are a number of hunting areas which the Yanomamö cannot exploit but which the Ye'kwana exploit regularly due to the possession of outboard motors which allow them to travel into areas which are rarely hunted and therefore abound in game. By knowing locational data on hunting input and output (described above), game taken and hunting time spent in areas not accessible to Yanomamö hunters can be systematically excluded from consideration. Finally, Ye'kwana and Yanomamö differ in hunting methods. By and large the Ye'kwana are riverine hunters who tend to exploit gallery and *igapó*[13] forest habitats which occur along the margins of large rivers. The Yanomamö are deep forest hunters who search for game in the *terra firme* habitat, an area of forest covering an estimated 95% of Amazonia (Meggers, 1973). Although both groups exploit both habitats, each has a preference; but because the riverine habitat covers such a small area, the Ye'kwana hunt more often in *terra firme*. Locational data collected in the field also allow me to control for this factor.

[12] The Yanomamö do not hunt at night because they lack headlamps and because they fear *bore*, nocturnal demonic beings who attack humans. Acculturated Yanomamö who live in Ye'kwana households, however, will hunt at night, but only in the company of Ye'kwana.

[13] *Igapó* is an area of forest located behind natural river levees which is inundated for 1½ to 3 months per year during the heaviest parts of the rainy season. Its plant association differs from *terra firme* or high forest, which is never flooded.

RESULTS

Differences in Animal Species Taken by Ye'kwana and Yąnomamö Hunters

A survey of all Ye'kwana and Yąnomamö animal kills shows a wide divergence in the number and kinds of animals, which is largely a function of differences in technology and method, and partially a function of hunting focus. Table II is a list of all animals killed by Ye'kwana and Yąnomamö hunters during my 216 day game capture survey. The list includes the name of each species, its average weight, total number killed, and the total weight of each species killed by Ye'kwana and by Yąnomamö hunters. Table III summarizes the information in Table II in terms of the number of each type of animal killed, the total weight, and its rank order. Although there are sharp differences as to which animals are most important in each hunting economy, there are also a number of similarities. Three large terrestrial animals (white-lipped peccaries, tapirs, and giant anteaters) comprise 58% of animals killed by weight for the Yąnomamö, but only 18% of the total number of animals killed. For the Ye'kwana, three species (spectacled caimans, white-lipped peccaries, and tapirs) comprise 45% of animals killed by weight, but only 16% of the total number of animals killed. It is evident, then, that both cultures depend on very few animal species for the bulk of hunting production, and the number of these species killed is quite small in relation to the total number of animals killed. If we order animals by type instead of species, slightly different results are obtained. The top three animal types killed by the Ye'kwana (reptiles, peccaries, and birds) make up 61% of all animals killed by weight and 74% of the total number of animals killed. For the Yąnomamö, three animal types (peccaries, tapirs, and edentates) make up 81% of all animals killed by weight and 37% of the total number of animals killed. Two of the top four animals (tapirs and peccaries) killed by both societies are the same.

The fact that the caiman is the most important game animal killed by the Ye'kwana, comprising 30% by weight of animal species killed, but only 2% of Yąnomamö kills, can be explained by differences in hunting method and technology. Caimans are very rare in the immediate environs of Toki (the closest kills were made 9.4 km away at the river-lake of Sedukurauwä) and are best hunted at night when they feed actively. The possession of outboard motors and headlamps allows the Ye'kwana to exploit caimans successfully while, conversely, the Yąnomamö lack of such technology is reflected in the relative unimportance of caimans in their hunting production. Another factor is the Ye'kwana's preference for hunting from canoes along the river, a method rarely employed by the Yąnomamö. The giant anteater is the third most important animal hunted by the Yąnomamö, comprising 10% by weight of all animals killed, while comprising only 2% by weight of all Ye'kwana kills. Its small importance in the Ye'kwana economy is due to a blanket prohibition on its consumption. Only two were taken by the Ye'kwana during my study, one of which was killed in the forest when a Ye'kwana's hunting dogs would not leave it alone. Its carcass was later retrieved by the Yąnomamö who have no taboo on its consumption. The other anteater was killed by a Ye'kwana for his two Yąnomamö wives but since he is Ye'kwana, he did not consume any of it.

The most significant difference between the kills of the two groups of hunters as related to shotgun and bow use is the larger number of arboreal and volant animals killed by the Ye'kwana in comparison to the Yąnomamö. This difference is due mainly to the superiority of the shotgun over the bow and arrow. Ross (1978: 12-13) implies that a poisoned dart or arrow is superior to the shotgun for killing monkeys and sloths because once these animals are killed by a shotgun blast, they often persist in hanging suspended from tree branches and are extremely difficult to retrieve. Conversely, if they are shot with a curare-covered projectile, they will release their grip and fall to the ground in about 5 to 10 minutes. I would agree that once a sloth or monkey has been shot with an arrow or dart, these implements are without doubt superior to the shotgun, but as is well known, killing animals is the primary difficulty in hunting, while retrieval is most commonly secondary. In order to test Ross's generalization, one must inspect the data in Table V. The data in Tables II, III, and IV demonstrate differences in animals killed as a result of the combined effects of technology, method, and hunting focus, which, as mentioned previously, differ significantly between the two populations. The data in Table V included only those animals killed during day hunts and in hunting zones which are traveled to on foot or in paddled canoe. Therefore, nearly all factors which could possibly influence hunting success, except for differences in the shotgun and the bow, are controlled. The clear superiority of the shotgun for killing birds and arboreal mammals is revealed in Table V. Ye'kwana hunters killed 171 birds (292 kg), 30 monkeys (138 kg), and three sloths and three collared anteaters[14] (35 kg) for a total of 465 kg of arboreal and volant game; the Yąnomamö, on the other hand, killed 36 birds (64 kg), 20 monkeys (72 kg), and five collared anteaters and one sloth (32.6 kg), for a total of 169.6 kg. The superiority of the shotgun over the bow is even more impressive when one realizes that the Yąnomamö expended 2,451 hours during the sampling period to make the above-mentioned kills in nearby hunting zones compared to only 1,202 (Tables VI and VII) for the Ye'kwana. (Of course, other animals were taken in nearby hunting zones and they are indicated in Table V.)

[14] Collared anteaters (tamanduas) are included here because they are chiefly arboreal in habit.

Table II. Ye'kwana and Yąnomamö Hunting Kills[a]

Common name	Scientific name	Avg. weight, kg	Number taken Ye'k.	Number taken Yąno.	Total weight (kg) Ye'k.	Total weight (kg) Yąno.
BIRDS	*AVES*					
	ARDEIDAE					
White-necked heron	*Ardea cocoi*	2.27	5	0	11.35	0
Heron	*Ahinga ahinga*	1.55	6	1	9.30	1.55
Egret	*Casmerodius albus*	1.59	23	0	36.57	0
	CRACIDAE					
Mutum	*Nothocrax urumutum*	1.82	4	0	7.28	0
Green-backed guan	*Penelope granti*	1.45	45	10	65.25	14.50
White-headed piping guan	*Pepile cumanensis*	1.55	52	2	80.60	3.10
Black currasow	*Pauxi pauxi*	3.86	94	15	362.84	57.90
Crestless currasow	*Mitu tomentosa*	2.45	21	2	51.54	4.90
	RHAMPHASTIDAE					
Toucan	*Rhamphastos sulfuratus*	1.59	1	0	1.59	0
White-throated toucan	*Rhamphastos tucanus*	0.80	47	7	37.60	5.6
	PSITTACIDAE					
Scarlet macaw	*Ara macao*	1.70	8	0	13.60	0
Mealy parrot	*Amazonica farinosa*	0.55	9	0	4.95	0
	TINAMIDAE					
Grey tinamou	*Tinamus tao*	1.18	18	0	21.24	0
Great tinamou	*Tinamus major serratus*	0.82	3	0	2.46	0
Red-legged tinamou	*Cripturellus noctivagus*	0.45	2	1	0.90	0.45
Tinamou	*Thersticus caudatus*	0.45	1	0	0.45	0
	(OTHERS)					
Ruddy pigeon	*Leptolila verreauxi*	0.41	4	0	1.64	0
Bokorama	?	1.82	1	0	1.82	0
Barn owl	*Tyto alba stricta*	0.45	2	2	0.90	0.90
White-tipped dove	*Columba subvinacea purpureotineta*	0.36	4	0	1.44	0
Limpkin	*Aramus guarauna*	0.77	2	0	1.54	0
Marbled wood quail	*Odonthophorus gujanesis*	0.30	1	0	0.30	0
Pauiweri	?	0.32	3	0	0.96	[illegible]
Semadi	?	0.45	2	0	0.90	0
Crimson-crested woodpecker	*Phloeoceastes melanolecus*	0.36	2	0	0.72	0
Grey-winged trumpeter	*Psophia crepitans*	1.0	45	2	45.00	2.00
Subtotal			405	42	762.74	90.90
REPTILES						
Black caiman	*Melanosuchus niger*	13.64	2	0	27.28	0
Spectacled caiman	*Caiman sclerops* (large)	43.64	23	0	1003.72	0
	(medium)	13.18	32	0	421.76	0
	(small)	3.64	41	1	149.24	3.64
Boa constrictor	*Boa constrictor imperator*	14.55	1	2	14.55	29.10
Wata (snake)	?	6.82	1	2	6.82	13.64
Tortoise	*Podocnemis unifilis*	1.45	2	3	2.9	4.35
Tortoise	?	0.95	0	5	0	4.75
Subtotal			102	13	1626.27	55.48
EDENTATES						
Three-toed	*Bradypus tridactylus*	8.64	2	1	17.28	8.64
Nine-banded armadillo	*Dasypus novemcintus*	5.45	17	12	92.65	65.4
Armadillo	*Pridontes giganteus*	30.00	2	1	60.00	30.00
Giant anteater	*Myrceophaga tridactyla*	40.91	2	5	81.82	204.55
Silky anteater	*Cyclopes didactylus*	0.91	1	0	0.91	0
Collared anteater	*Tamandua tetradactyla longicuadata*	5.00	3	10	15.00	65
Subtotal			27	32	267.65	373.59
CAVIOMORPH RODENTS						
Agouti	*Dasyprocta aguti lunaris*	3.64	10	20	36.40	72.8
Picure	*Dasyprocta fuliginosa*	1.36	6	5	8.16	6.8
Paca	*Cuniculus paca*	8.41	45	3	378.45	25.23
Capybara	*Hydrochoerus hydrochoerus*	48.18	1	0	48.18	0
Subtotal			62	28	471.19	104.83

(continued)

Table II. Continued

Common name	Scientific name		Avg. weight, kg	Number taken		Total weight (kg)	
				Ye'k.	Yąno.	Ye'k.	Yąno.
TAPIRS	TAPIRADAE						
Tapir	*Tapirus terrestrius*	(large)	227.27	3	1	681.81	227.27
		(small)	163.64	0	1	0	163.64
Subtotal				3	2	681.81	390.91
PECCARIES	TAYASSUIDAE						
White-lipped peccary	*Tayassu pecari*	(large)	36.36	18	22	654	799.9
		(small)	27.27	2	0	54.54	0
Collared peccary	*Tayassu tacaju*	(large)	17.27	7	9	120.89	155.43
		(small)	11.36	0	1	0	11.36
Subtotal				27	32	829.91	966.71
MONKEYS	CEBIDAE						
Red howler monkey	*Alouatta seniculus*		7.27	11	2	79.97	14.54
Window monkey	*Callicebus torquatus lugens*		1.00	17	0	17.00	0
Saki	*Pithecia chiropes*		1.14	9	2	10.26	2.28
Long-haired spider monkey	*Ateles belzebuth*		9.66	13	1	125.58	9.66
White monkey	*Cebus apella fatuellus*		4.09	29	13	122.70	53.17
Subtotal				79	18	351.41	79.65
OTHERS							
Brocket deer	*Mazama nemoriaga*	(large)	39.09	1	1	39.09	39.09
		(small)	22.73	1	0	22.73	0
Swamp deer	*Mazama rufina*		45.00	3	0	135.00	0
Coati	*Nasua narica*		1.82	3	3	5.46	5.46
Kinkajou	*Pothos flavus*		0.45	1	1	0.45	0.45
Squirrel	*Hadroscicerus igniventris*		0.45	1	1	0.45	0.45
Jaguar	*Panthera onca*		43.64	1	1	43.64	43.64
Ocelot	*Felis melanarus*		8.18	0	1	0	8.18
Otter	*Pteroneau brasiliensis*		7.27	1	0	7.27	0
Subtotal				12	8	254.09	97.27
Total				726.3	154.6	5231	2170

[a] Data were derived from a 216-day game capture study which took place during three separate study periods from August, 1975 to June, 1976.

Table III. Rank Order by Weight of Animals Killed by Ye'kwana and Yąnomamö Hunters During the 216 Day Sample Period

Animal	Total killed, kg	Percent of total
Ye'kwana kills		
Caiman	1602.00	30.2
White-lipped peccary	690.84	13.0
Tapir	681.81	12.8
Paca	379.45	7.1
Black currasow	362.84	6.8
Brocket deer	135.00	2.5
Long-haired spider monkey	125.58	2.4
White monkey	122.70	2.3
Collared peccary	120.89	2.3
Armadillo, nine-banded	103.55	1.9
White-headed piping guan	87.45	1.6
Red howler monkey	87.24	1.6
Giant anteater	81.82	1.5
Green-backed guan	65.25	1.2
Swamp deer	61.82	1.2
Giant armadillo	60.00	1.1
Yąnomamö kills		
White-lipped peccary	763.56	37.0
Tapir	390.91	18.9
Giant anteater	204.55	9.9
Collared peccary	166.79	8.1
Agouti	69.16	3.4
Black currasow	57.90	2.8
Armadillo, nine-banded	54.50	2.6
White monkey	49.08	0.4
Collared anteater	50.00	0.2
Jaguar	43.64	0.2
Brocket deer	39.09	0.2
Boa constrictor	29.10	0.1

The superiority of the shotgun in killing arboreal and volant game is a combined function of its range, projectile spread, and the user's ability to hit moving targets. Table I shows that the shotgun has an 18 m advantage over the bow for killing birds and small game. Its greater range is probably related to a projectile spread of 1 m or more in diameter (Dalrymple, 1973) at 30 m. Also, when hunting arboreal game one cannot shorten shooting distance by expert stalking. In effect, even though a bow hunter can spot game, he must pass by when it is out of range. While shotgun hunters have no hesitancy in doing so, bow hunters will not even attempt a shot at moving arboreal or volant game. Finally, whereas arrows can be deflected easily by branches and stems, one can fire a shotgun through dense vegetation with some confidence that at least a few pellets will reach the target.

Table IV. Rank Order by Class of Animals Killed by Ye'kwana and Yąnomamö Hunters During the 216 Day Sample Period

Class	Number of animals killed	Total killed, kg	Percent of total
Ye'kwana kills			
Reptilia	103	1627.72	30.6
Tayassuidae	27	866.27	16.3
Aves	405	762.74	14.4
Tapirdae	3	681.81	12.8
Caviomorphs	63	472.55	8.0
Cebidae	79	365.06	6.9
Edentates	29.3	281.15	5.3
Other	12	254.09	4.7
Total	721.3	5311.39	99.9
Yąnomamö kills			
Tayassuidae	32	930.35	45.1
Tapirdae	2	930.91	18.9
Edentates	26.6	344.23	16.7
Caviomorphs	26	99.83	4.8
Other	8	97.27	4.7
Aves	42	90.90	4.4
Cebidae	18	66.01	3.2
Reptilia	8	44.36	2.1
Total	162.6	2063.86	99.9

There are several other differences in the number of specific animals taken by Ye'kwana and Yąnomamö hunters, some of which are significant. Ye'kwana hunters took more pacas (45 to 3) because these animals are active at night (25 of the pacas were killed at night). The Yąnomamö took more anteaters and snakes because the Ye'kwana have taboos against eating these animals.[15] All other differences in kills are probably a result of chance encounters.

As mentioned above, Ross (1978) has made the surprising claim, in his explanation of Amazonian hunting taboos, that the bow is superior to the shotgun for killing big game such as capybaras, deer, and tapirs. While several reviewers who commented on the article suggested that this generalization is manifestly not the case, they gave only anecdotal evidence to the contrary. The data presented in Table V, as mentioned previously, exclude game taken at night and in distant hunting zones and allow us to test this generalization by comparing the total kilograms of such game killed by the Ye'kwana and by the Yąnomamö.

[15]Although the Ye'kwana also prohibit the consumption (but not the killing) of giant anteaters, giant armadillos, coatis, and otters, they ironically killed more of these animals than did the Yąnomamö. However, the Ye'kwana always gave the animals to Yąnomamö who reside in their houses.

Table V. Game Taken by Yąnomamö and Ye'kwana Hunters During Day Hunts and in Hunting Zones Accessible by Foot or Paddled Canoe

Species	Number of animals killed	Total killed, kg
Ye'kwana kills		
Large ungulates (tapir, deer, and capybara)	7	620
Peccaries	14	443
Birds	171	292
Monkeys	30	138
Caviomorph rodents	25	125
Edentates	12	101
Other	13	76
Total	272	1795
Yąnomamö kills		
Peccaries	12	311
Large ungulates (tapir, deer, and capybara)	2	266
Edentates	25	199
Other	20	108
Caviomorph rodents	29	97
Monkeys	20	72
Birds	36	64
Total	144	1117

Ye'kwana hunters killed 620 kg of capybara, deer, and tapir, compared to 266 kg for the Yąnomamö. This difference is even more significant when one realizes that the Yąnomamö spent approximately 100% more time hunting in these zones (cf. Tables VI and VII). It is safe to say that the shotgun is a superior weapon to the bow for killing any animal. Possibly Ross was drawn to his conclusion by the much touted ability of the arrow to penetrate more deeply than shotgun pellets into animals. But the quality of the hunting weapon is measured by its ability to kill any animal under a variety of circumstances. As mentioned above, the lanceolate bamboo point used on Yąnomamö arrows will break or glance off bone near the surface of the skin, but a large shotgun pellet will shatter bone. A well placed shotgun blast can wound an animal in several places simultaneously while an arrow can wound in only one place. Table I shows that the shotgun has a 4 m range advantage for killing large game and, although this distance may not seem great, it is enough to make for more successful hunting. I could go on discussing advantages and disadvantages of each weapon, but the proof of the pudding is the amount of large game taken, and in this respect the shotgun proves superior.

Table VI. Ye'kwana Hunting Input, Output, and Input/Output Ratio During the 216 Day Game Capture Study

Hunter	Days in village	Average time spent hunting, min/day			Estimated total hours spent hunting			Game captured, kg	Input/output ratio, kg game/hr
		Near zones	Far zones	Total	Near zones	Far zones	Total		
Jaime	120	12.7	29.6	42.3	25.0	59.3	84.3	726.3	8.62
Julio	149	76.6	34.0	110.6	190.2	84.4	274.7	1014.9	3.69
Enrique	209	45.0	15.0	60.0	156.7	52.3	209.0	599.5	2.87
Turin	190	54.0	22.0	76.0	171.0	69.7	240.7	567.5	2.36
Sixto	195	48.0	39.0	87.0	156.0	126.8	282.8	665.0	2.35
Nelson	127	24.0	13.5	37.5	50.8	28.6	79.4	193.1	2.43
Jose	78	52.0	10.4	62.4	67.6	13.5	81.1	182.5	2.25
Jacobo	78	6.8	48.0	54.8	8.8	62.4	71.2	148.2	2.08
Waiyamoa	74	86.0	23.0	109.0	106.1	28.4	134.4	185.1	1.38
Felipe S.	73	68.0	48.0	116.0	82.7	58.4	141.1	178.2	1.26
Wakawä	139	24.0	4.0	28.0	55.6	9.3	64.9	79.5	1.22
Mario	170	23.0	24.0	47.0	65.2	68.0	133.2	158.3	1.19
Pedro	124	7.8	15.0	22.8	16.1	31.0	47.1	50.5	1.07
Cecilio	162	18.9	12.5	31.4	51.0	33.8	84.8	27.3	0.32
Total		546.8	338.0	884.8	1202.8	725.9	1928.7	4775.9	
Average	134.9	39.1	24.1	63.2	85.9	51.9	137.8	341.1	2.48

Input/output ratio, near zones = 1.49 kg game/hr
Input/output ratio, far zones = 4.84 kg game/hr

Table VII. Yąnomamö Hunting Input, Output, and Input/Output Ratio During the 216 Day Game Captured Study

Hunter	Days in village	Average time spent hunting, min/day: Near zones	Far zones	Total	Estimated total hours spent hunting: Near zones	Far zones	Total	Game captured, kg	Input/output ratio, kg game/hr
Huyashiwa	179	58.5	8.3	66.8	174.5	24.7	199.2	402.7	2.02
Shitibäwä[a]	30	53.0	13.0	66.0	26.5	6.5	33.0	61.4	1.86
Barahi	198	54.0	12.3	66.3	178.2	40.6	218.8	327.3	1.50
Heashima	65	30.3	12.0	42.3	32.8	13.0	45.8	44.5	0.97
Matäwä	176	91.0	58.0	149.0	266.9	170.0	437.0	291.1	0.67
Mashitäwä	189	84.0	55.0	139.0	264.6	173.3	437.9	290.6	0.66
Moroshitabawa	216	113.0	52.0	165.0	406.8	187.2	594.0	248.6	0.42
Mamowaima	201	126.0	59.0	185.0	422.1	197.7	619.8	249.2	0.40
Kawaiyu[b]	162	90.0	9.0	99.0	243.0	24.3	267.3	79.72	0.35
Davio	50	49.0	138.0	187.0	40.8	115.0	155.8	45.8	0.29
Waiyoboliwä	194	88.0	58.0	146.0	284.5	187.5	472.0	67.8	0.14
Badaawai	161	51.0	48.0	99.0	136.9	128.8	265.7	17.3	0.07
Total		834.8	509.6	1344.4	2451.1	1262.1	3713.3	2126.0	
Average	162.8	75.9	46.3	122.2	222.8	114.7	337.6	189.0	0.57

Input/output ratio, near zones = 0.46 kg game/hr
Input/output ratio, far zones = 0.76 kg game/hr

[a] Yąnomamö visitor who hunted mainly with a shotgun and stayed in the village for only 30 days. His totals are not included in the caculation of the totals and averages because he visited only to help the Toropo-teri prepare for a *reahu* festival.
[b] Yąnomamö who lived in a Ye'kwana household but hunted with a bow full time.

Variations in hunting time expenditure, game taken, and hunting efficiency are determined in part by technology and in part by demographic and social factors. Here I will consider only those Ye'kwana and Yąnomamö hunters who are regular full-time hunters, which excludes all women, boys under 15 years of age, and village members or visitors who did not spend enough time in the village for a statistically significant estimate of their hunting activities to be made. Since the Yąnomamö do not have outboard motors which would permit them to hunt in distant hunting zones or headlamps which would allow them to hunt at night, data are presented which excludes the effects of this technology on hunting for both populations, i.e., observations of night hunting and hunting in distant zones are not included.[16] The data will be compared to a Yąnomamö subpopulation studied by Lizot (1978), the bow-hunting Wayana (La Pointe, 1971), and the shotgun-hunting Siona-Secoya (Vickers, 1976).

Tables VI and VII show that Yąnomamö hunters spend an average of 122 minutes per day hunting while the Ye'kwana spend only 63 minutes per day. These figures are somewhat inflated, on a daily basis, because they are limited to those observations when a hunter was living in the village. If one were to include observations when hunters were outside of the village visiting other villages or on trading or raiding expeditions, then the figures would be 15 to 40% lower. This is especially the case for the Yąnomamö: even though they spent 94% more minutes per day hunting, they logged 145% more hours during the sampling period simply because they travel less frequently than the Ye'kwana. Lizot's (1978: 89) economic study of a Yąnomamö village approximately 25 miles east of my site showed that they expended, on the average, between 64 and 85 minutes per day hunting, depending on the season. The figures on the Yąnomamö of Toropo-teri are quite a bit higher due to the fact that they went on three separate overnight hunting expeditions (one of which lasted 6 days) in order to supply meat for more than 100 guests from three allied villages for a *reahu* or mortuary ceremony. One expedition would have sufficed, but their guests, at the last moment on two occasions, did not attend for fear of enemy raiders in their own areas, and on the third occasion only a handful attended the twice-delayed *reahu* ceremony.

Nevertheless, most of the difference in hunting time between the Yekwana and the Yąnomamö is a result of technology. We may regard the outboard motor, the headlamp, and the shotgun as labor-saving devices. Outboard motors allow the Ye'kwana to shorten travel time and also to penetrate into hunting zones that are rarely hunted and therefore abound in game. Headlamps permit night hunting, which is the most productive of all hunting techniques (Hames,

[16] However, all kills are presented in Table II.

1978). And, the shotgun, as I will discuss below, is much more effective than the bow. These three examples of modern technology make hunting more productive (in terms of kilograms of game taken per hour of hunting), thereby dampening the need to hunt more frequently.

Variation in hunting input and output among Ye'kwana and Yąnomamö hunters is also a result of social and demographic factors, such that those men who have a large number of dependents must hunt more often than those with few dependents to provide with meat.[17] Also, young Yąnomamö men providing bride-service must prove their worthiness for marriage to their bride's family by hunting often and successfully (cf. Chagnon, 1969). Married men between the ages of 20 and 40 are the main suppliers of meat to their households. In general, although they are still heads of households, men over the age of 40 do very little hunting because they have sons or sons-in-law who are required to contribute the bulk of hunting production. Seeming to be exceptions to the generalization that men over 40 produce little meat are the Ye'kwana hunter, Julio, and the Yąnomamö hunter, Huyashiwä. These men killed more game than any other Ye'kwana or Yąnomamö hunter, respectively. Julio's exceptionality actually proves the rule because he married late and has 10 dependent children, none of whom can contribute significantly to the family's meat production. When his step-son, Jose (cf. Table VI), returned to Toki after a long absence, Julio sharply curtailed his hunting efforts.

Chagnon has noted that Yąnomamö hunting success "depends as much on luck as it does on skill" (Chagnon, 1969: 33), and Siskind (1973) makes a similar observation on the Sharanahua of Peru. The good fortune of encountering large ungulates is often unpredictable and decisively influences one's hunting production. For example, killing a single adult tapir would account for 67% of all game by weight for an average Ye'kwana hunter over the 216 day sampling period and an impressive 120% for a Yąnomamö hunter. This factor explains why Huyashiwä killed more game than any other Yąnomamö despite his age: he had the good luck to encounter a tapir. But luck influences hunting success only over the short run (with a sufficiently long sample, one would expect luck to be distributed equally among all hunters) and it is the great variation in individual hunting skills which ultimately determines hunting success.

The input/output data in Tables VI and VII for hunting efficiency in near, far, and all hunting zones combined quantitatively demonstrates the difference that Western technology makes in neotropical forest hunting. Without controlling for hunting location and technology, we find that the Ye'kwana gain 343% or 1.92 more kilograms of game per hour of hunting than the Yąnomamö. It seems safe to say that this difference in hunting efficiency is due entirely to the shotgun, outboard motor, and headlamp. However, from the point of view

[17] This factor is directly analogous to Chayanov's concept of self-exploitation (1966). See Sahlins (1972) for a discusson in relation to primitive subsistence agriculture.

Table VIII. Input, Output, and Input/Output Ratio for Ye'kwana and Yąnomamö Hunters Who Used Both the Shotgun and the Bow

Hunter	Weapon	Time spent hunting, min/day	Total hours spent hunting	Game captured, kg	Input/output ratio, kg game/hr
Enrique[a]	Bow	53	179	165.0	0.92
Enrique	Shotgun	60	208	599.5	2.88
Wakawä[b]	Bow	79	183	55.9	0.31
Wakawä	Shotgun	28	65	79.5	1.22
Shitibawä[b]	Bow	66	33	8.2	0.25
Shitibawä	Shotgun	198	100	61.4	0.61

[a] Ye'kwana hunter.
[b] Yąnomamö hunter.

of this study, the crucial question is, What difference does the shotgun alone make in hunting? In order to compare directly the efficiencies of the two weapons, all Ye'kwana input and output from night hunting and hunting in distant zones that must be reached by motor-powered canoes must be eliminated from the comparison. Similarly, all Yąnomamö hunting in distant zones not usually hunted by the Ye'kwana must also be excluded. What remains are only those zones which are reached by paddle canoe or by foot. The columns in Tables VI and VII entitled "Near zones" and "Far zones" indicate the amount of time each Ye'kwana and Yąnomamö spent in each of these areas. By combining these figures with the amount of game taken in each zone, we find that the Ye'kwana gain an input/output ratio of 1.49 kg of game per hour of hunting in near zones, while the Yąnomamö gain only 0.45 kg of game per hour of hunting in near zones. Thus, the shotgun is 231% more efficient than the bow in near zones. Table VIII reinforces this evidence by showing the input/output analysis of three hunters who hunted alternately with the shotgun and the bow. The generalization that hunting success usually increases with distance from the village is borne out in the input/output ratios for near and far zones, which show that the Ye'kwana increase their hunting efficiency in far zones by 225% over near zones and the Yąnomamö increase their efficiency by 69% (Tables VI and VII). The rate of increase by the Yąnomamö is much lower because although the game in their distant zones may be as plentiful as in Ye'kawana distant hunting zones, more time must be devoted to travel because the Yąnomamö lack outboard motors for their canoes.

The input/output ratios of Yąnomamö and Ye'kwana hunters are similar to the ratios I have calculated for the bow-hunting Wayana (La Pointe, 1971) and the shotgun-hunting Siona-Secoya (Vickers, 1976), both of whom exploit ecosystems very similar to the Upper Orinoco. The Wayana kill game at a rate of 0.63 kg/hr compared to 0.56 kg/hr for the Yąnomamö. The rate of the Siona-Secoya, 2.84 kg/hr, compares favorably to 2.48 for the Ye'kwana. It is difficult to understand why the data on the Wayana and the Siona-Secoya are so close to those on the Ye'kwana and Yąnomamö. Nevertheless, the significance of these comparisons is that the magnitude of difference between the shotgun and the bow in hunting efficiency may be rather constant throughout Amazonia.

DISCUSSION

The transition from the bow and arrow and other traditional hunting technology to the shotgun has had a number of important effects on Ye'kwana life, and on local animal populations. It seems warranted to assume that certain aspects of Ye'kwana life once resembled those of the Yąnomamö, so that the Yąnomamö may serve as a sort of baseline from which to understand these changes. Basically the shotgun, along with other Western technological devices, is altering Ye'kwana economic life and changing the distribution of certain game resources.

The most visible and immediate effect of the shotgun on Ye'kwana life is a decrease in the amount of time spent hunting. Tables VI and VII show that Ye'kwana hunters spend 59 fewer minutes per day hunting than the Yąnomamö. The obvious explanation for this decrease is the increase in hunting efficiency caused by the shotgun. But, unfortunately for the Ye'kwana, increasing dependence on the shotgun and related hunting equipment causes a loss of technological autonomy and most probably an overall increase in time input in other economic endeavors. Since the Ye'kwana can no longer manufacture their own weapons of the hunt, they are dependent upon the Venezuelan national economy. To insure a steady supply of shotguns and ammunition, they must grow cash crops. This places them in a potentially unstable position because if the demand for their cash crop of manioc farina falls or the supply of firearms diminishes,[18] it will become increasingly difficult to hunt as they do presently. Due to cash-cropping, Ye'kwana adult males and females spend an average of 29 and 60 more minutes per day, respectively, on agricultural activities than do their Yąnomamö counterparts. The increase in labor has been largely assumed by women since they do most of the garden work traditionally, but it is rather ironic that in effect they must work harder so that men may purchase firearms which allow them to hunt more efficiently and therefore less frequently. However, it is quite difficult to estimate what portion of that time is devoted to earning cash to purchase only industrially manufactured hunting technology, since a great deal of the cash earned is used to purchase clothing, steel tools, aluminum kettles, outboard motors, gasoline, fishing tackle, and other goods not directly related to hunting. I believe that the amount of time saved by using shotguns for hunting is only slightly less than the extra amount of time that must be devoted to cash-cropping in order to pay for this added luxury.

[18] Current national Venezuelan law prohibits the sale of firearms and their accessories for hunting by nonaboriginal peoples in Amazonas. In practice, this law has not prevented the sale of firearms in the area but has merely driven up the prices and put native people who have come to depend upon them in a precarious economic position. Furthermore, the chief purchasers of Ye'kwana manioc, and therefore the means of gaining cash for firearms, are the numerous Catholic Salesian Missions in the Upper Orinoco. As I was leaving the field, two missions were planning to close, leaving the Ye'kwana with fewer sources of cash with which to purchase ammunition.

The impact of the shotgun on traditional technology is one of simplification, since shotguns are excellent all-purpose tools that have replaced a host of traditional and specially designed hunting implements, such as bows and arrows, blowguns, lances, clubs, and traps. The machete and steel axe have had similar effects on other parts of the economy. However, due to the unreliable supply of ammunition, the Ye'kwana (especially Enrique, Table VIII) have maintained their expertise with the bow and arrow, thus allowing some room to maneuver. Furthermore, Ye'kwana boys between the ages of 8 and 13 begin to hone their hunting skills with the blowgun, graduate to the bow between the ages of 12 and 16, and finally, when the most important skills of hunting (i.e., tracking and stalking) are mastered, they begin to hunt with the shotgun.

It should be obvious that the shotgun has a much greater impact on some animal populations than does the bow. Volant and arboreal species have suffered most because they are most susceptible to the shotgun: the Ye'kwana killed about six times as many of these animals by weight as did the Yąnomamö. Night hunting with headlamps has taken a huge toll on the spectacled caiman (*Caiman sclerops*); and the black caiman (*Melanosuchus niger*), although never common in the basin, is in danger of being exterminated. Sixty-eight of the 96 spectacled caiman killed were taken at night. The paca (*Cuniculus paca*) is also successfully hunted at night (25 of the 45 killed by the Ye'kwana were taken at night) and the Ye'kwana killed far more than the Yąnomamö (who killed only three). However, careful analysis of locational data reveals that most of the pacas were killed quite near the village, indicating that not too large a dent has been made in their population.[19] In contrast, 83% of all caiman kills were made at least 9.4 km from the village, while 74% of all pacas were taken less than 2 km from Toki. Finally, the snowy egret (*Ardea cocoi*) is becoming scarce in the Padamo and already is extremely scarce in the Upper Orinoco above the Ocamo River (Lizot, personal communication). As mentioned previously, this large and beautiful bird is easy to hunt by canoe.[20]

[19] See Linares (1976) for a discussion of paca hunting by sedentary horticultural villages in pre-Columbian Costa Rica.

[20] These birds are never the target of serious hunting but are killed only when the opportunity presents itself. Some kills are made while traveling to gardens and gathering spots.

The shotgun has apparently had less of an impact on large terrestrial game such as deer, peccaries, tapirs, and capybaras. Even so, as noted above, the Ye'kwana harvested more than twice as many of these animals as did the Yąnomamö. These animals are the mainstays of Indian diets and their availability greatly affects total protein consumption. According to tropical forest ecological research (e.g., Gómez-Pompa, 1973), these animals have low reproductive rates and do not migrate readily (except for the white-lipped peccary), making local extinction a real possibility. Ross (1978) explains Achuara Jívaro hunting taboos on large terrestrial animals (deer, tapiers, capybaras, but not white-lipped peccaries) by using the same reasoning: the Jívaro focus on small game because large game is difficult to hunt due to its scarcity which has been caused by overexploitation and the inability to reproduce rapidly. Even though the Padamo has been continually hunted for at least the last 200 years and the vicinity of Toki has been hunted for at least 35 years, the population of big game apparently has not suffered greatly. My locational data reveal that four of the six deer and three of the five tapirs killed were captured less than half a day's walk from Toki. This is not to say that heavy inroads have not been made on large animal populations, but it does suggest that despite long-term settlement, big game is still sufficiently abundant near Toki to comprise a significant portion of the diet.

I seriously doubt that the Ye'kwana will be able to rely on the caiman as the main source of meat protein for very much longer (it presently comprises 30% by weight of all game killed). The most important reason for hunting caimans is that they are still the most productive animals to hunt, even though one must travel far to find them. Eventually, the Ye'kwana will have to change their hunting focus. The main method the Ye'kwana and Yąnomamö employ to deal with a decreasing supply of game is to abandon unproductive hunting zones and open new ones. Abandonment of a hunting zone is not done because of any moral or religious feeling towards the animals that are being decimated in a particular area. Rather, zones are abandoned simply because the amount of effort expended is not sufficiently returned in hunting success. Hunting zones nearest the village have the least game, while zones furthest away have the most game, because the near areas were once hunted heavily and game has become scarce (Hames, 1978). The Ye'kwana and Yąnomamö have almost completely abandoned several once-rich hunting areas that are only an hour's walk from the village because of game depletion, and they have opened two new hunting zones which are the most productive of all areas.[21] It is interesting to note, however, that both of these new areas were inhabited and hunted 15 to 20 years ago by a number of Ye'kwana and Yąnomamö villages. Apparently, this length of time was sufficient for game populations to return to fairly high levels. The work of Vickers (1976) on the Siona-Secoya of the Peruvian Amazon provides some support for this idea. The Siona-Secoya moved into an area that had not been exploited for decades and therefore abounded in game. Their hunting success, measured in kilograms of butchered game per hunt, was quite similar to that for the Ye'kwana when they hunted in a similar environment which had not been exploited for years (21.35 kg per hunt for the Siona-Secoya compared to approximately 30 kg per hunt for the Ye'kwana). With data like these, it may be possible to compute a carrying capacity for hunting much like what Carneiro (in preparation) has recently proposed.

Bennett's monograph (1968) on human exploitation and destruction of game animals in Panama is the most comprehensive account of its kind for the neotropics. Due to a tremendous increase in human population density over aboriginal conditions, which led to deforestation through logging, farming, commercial hunting, and increased subsistence hunting, the native fauna of Panama (which has many species in common with Amazonian Venezuela) has become impoverished throughout the country and in many places local extinction of important game animals has occurred. If present conditions in the Upper Orinoco continue, there is little possibility of faunal impoverishment occurring, for two reasons. First, the population density of the Upper Orinoco is so low (less than 0.2 persons per square km) that it would be difficult for native populations to make a serious dent in animal populations, given the mobility of village settlements, which has the unintended effect of taking pressure off hunting zones. Second, Ye'kwana and Yąnomamö hunters are subsistence hunters and the demand they make on faunal resources is governed by local and finite needs and not, for example, by the seemingly insatiable needs of international fur, skin, and feather dealers, not to mention the demand of biological institutions and zoos for live specimens.[22]

Apparently South American Indian meat needs are satiable. Among the Jívaro, Harner notes that although the introduction of the shotgun has greatly increased hunting efficiency, "there is similarly no evidence that the meat supply produced by hunting [with the shotgun] has increased" (Harner, 1968b: 379). Vickers' study of the Siona-Secoya makes the same point (Vickers, 1976: 142-144). A comparison of per capita consumption of protein derived from hunting between the Ye'kwana and the Yąnomamö is also consonant with the above. In spite of the fact that the Ye'kwana are 343% more efficient in hunting than the Yąnomamö, per capita consumption of meat from the hunt is only 16% greater.[23]

[21] Feit (1973) and Jarvenpa (1977) describe a similar process of hunting group rotation among the Athabaskan hunter-gatherers of Canada.

[22] Although the Ye'kwana took 1,602 kg of caiman, none of the skins was sold.

[23] See Chagnon and Hames (1979) for a discussion of animal protein consumption in Amazonia.

CONCLUSION

In summary, my results indicate that the shotgun is a far superior hunting implement to the bow, and when the shotgun is coupled with other technological innovations such as headlamps and outboard motors its efficiency increases further. However, the use of the shotgun is not without its drawbacks. Its continued use leads to a loss of economic autonomy through cash-cropping, forcing an increase in the amount of time spent on other economic activities. Thus far the shotgun has not caused a serious decline in game populations, except for the spectacled and black caimans, for two interrelated reasons. The population density in the Padamo River Basin is sufficiently low at 0.2 persons per square km to make overexploitation extremely difficult; and the practice of rotating hunting zones allows game populations to rebuild after intensive hunting, while hunting zones which offer better returns per expenditure are reopened for intensive hunting. Finally, in spite of the fact that the Ye'kwana are 343% more efficient in hunting than the Yąnomamö, their total protein consumption of game is only 16% higher. This fact suggest that although the Ye'kwana could allocate more time to hunting, they do not because they consider their protein intake adequate. Therefore, one may hypothesize that to some extent time allocated to hunting is limited by hunting success (or efficiency), thus preventing overexploitation. In order to gain an equal amount of protein, the Yąnomamö must hunt much more often and intensively.

ACKNOWLEDGMENTS

I would like to thank David Brokensha, Bob Carneiro, Tom Foor, Ilene Hames, Bernard Nietschmann, and Larry Wilcoxon for reading the manuscript and offering useful criticism.

REFERENCES

Altmann, J. (1974). Observational study of behavior: Sampling methods. *Behaviour* 48: 1-41.

Beckerman, S. (1978). Comment on Ross. *Current Anthropology* 19(1): 17-18.

Bennett, C. F. (1968). *Human Influences on the Zoogeography of Panama*. Ibero-Americana, No. 51. University of California Press, Berkeley.

Butt-Colson, A. (1973). Inter-tribal trade in the Guiana Highlands. *Antropologica* 34: 1-70.

Carneiro, R. L. (in preparation). Game depletion and village movement, a quantitative approach.

Chagnon, N. A. (1969). *Yąnomamö: The Fierce People*. Holt, Rinehart and Winston, New York.

Chagnon, N. A., and Hames, R. B. (1979). Protein deficiency and tribal warfare in Amazonia: New data. *Science* 203(4383): 910-913.

Chayanov, A. V. (1966). In Thorner, D., Kerblay, B., and Smith, R. E. F. (ed. and trans.), *The Theory of Peasant Economy*, Richard D. Irwin, Homewood, Ill.

Cranstone, B. (1972). The Tifalmin: A neolithic people in New Guinea. *World Archaeology* 3(2): 132-142.

Dalrymple, B. (1973). *The Complete Book of Deer Hunting*. Winchester Press, New York.

de Barandiaran, D. (1962). Actividades vitaes de subsistencia de los indios Yekuana o Makiritare. *Antropologica* 11: 1-29.

de Civrieux, M. (1970). *Watuuna Mitologia Maquiritare*. Monte Avial Editors, Caracas, Venezuela.

Draper, P. (1977). Social and economic constraints on child life among the !Kung. In Lee, R. B., and Devore, I. (eds.), *The Kalahari Hunter Gatherers*, Harvard University Press, Cambridge, Mass. pp. 200-217.

Dunbar, R. I. M. (1975). Some aspects of research design and their implications in the observational study of behaviour. *Behaviour* LVIII(1-2): 78-98.

Erasmus, C. (1955). Work patterns in a Mayo village. *American Anthropologist* 57(2): 322-334.

Erasmus, C. (1965). Monument building: Some field experiments. *Southwestern Journal of Anthroplogy* 21(4): 277-301.

Feit, H. (1973). The ethno-ecology of the Waswanipi Cree: Or how hunters can manage their resources. In Cox, B. (ed.), *Cultural Ecology: Readings on the Canadian Indians and Eskimos*, McClelland and Stewart, Toronto, Canada, pp. 115-124.

Gillin, J. (1936). *The Barama River Caribs of British Guiana*. Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University, Cambridge, Mass.

Gómez-Pompa, A. (1973). Recovery of tropical ecosystems. In Farnworth, E. G., and Golley, F. B. (eds.), *Fragile Ecosystems*, Springer-Verlag, New York, pp. 113-138.

Good, K. (1978). Comment on Ross. *Current Anthropology* 19(1): 20-21.

Hames, R. B. (1978). A Behavioral Account of the Division of Labor among the Ye'kwana Indians of Southern Venezuela. PhD dissertation, University of California, Santa Barbara, August 1978.

Hamilton, T. M. (1972). *Native American Bows*. George Shumway Publishers, York, Pa.

Harner, M. (1968a). *The Jívaro (People of the Sacred Waterfall)*. Doubleday-Natural History Press, Garden City, New York.

Harner, M. (1968b). Technological and social change among the Eastern Jívaro. *XXXVII International Congress of Americanists*, Buenos Aires, Argentina, pp. 363-388.

Holmberg, A. (1950). *Nomads of the Longbow: The Siriono of Eastern Bolivia*. Smithsonian Institution Publications of the Institute of Social Anthropology, No. 10 (reprinted 1969, Natural History Press, Garden City, New York).

Holmberg, A. (1954). Adventures in culture change. In Spencer, R. F. (ed.), *Method and Perspective in Anthropology: Papers in the Honor of W. D. Wallis*, University of Minnesota Press, Minneapolis, Minn., pp. 54-68.

Jarvenpa, R. (1977). Subarctic Indian trappers and band society: The economics of male mobility. *Human Ecology* 5(3): 223-260.

Johnson, A. (1975). Time allocation in a Machiguenga community. *Ethnology* 14(3): 301-310.

Kemp, W. (1974). The flow of energy in a hunting society. In Katz, S. (ed.), *Biological Anthropology*, W. H. Freeman, San Francisco, pp. 359-370.

La Pointe, J. (1971). *Residence Patterns and Wayana Social Organization*. PhD thesis, Columbia University, New York. Mich. Micro. No. 71-17516.

Linares, O. (1976). "Garden hunting" in the American tropics. *Human Ecology* 4(4): 331-350.

Lizot, J. (1972). Poisons Yanoami de chasse, de guerre, et de peche. *Antropologica* 31: 3-20.

Lizot, J. (1978). L'économie primitive. In Gauchet, M. (ed.), *Libre - 4 Payot*, Paris, pp. 69-114.

Meggers, B. J. (1973). *Amazonia: Man and Culture in a Counterfeit Paradise*. Aldine, Chicago.

Murphy, R. F. (1960). *Headhunter's Heritage*. University of California Press, Berkeley.

Nietschmann, B. (1973). *Between Land and Water (The Subsistence Ecology of the Miskito Indians, Eastern Nicaragua)*. Seminar Press, New York.

Nietschmann, B. (1978). Comment on Ross. *Current Anthropology* 19(1): 23-24.

Pope, S. (1923). A study in bows and arrows. *University of California Publications in American Archaeology and Ethnology*, Vol. 13.

Ross, E. B. (1978). Food taboos, diet, and hunting strategy: The adaptation to animals in Amazonian cultural ecology. *Current Anthropology*, 19: 1-36.

Ruddle, K. (1970). The hunting technology of the Maraca Indians. *Antropologica* 25: 21-63.

Sahlins, M. D. (1972). *Stone Age Economics.* Aldine, Chicago.

Salisbury, R. (1962). *From Stone to Steel.* Cambridge University Press, Cambridge, England.

Saraydar, S. C., and Shimada, I. (1971). A quantitative comparison of efficiency between a stone and steel axe. *American Antiquity* 36(2): 216-217.

Saraydar, S. C., and Shimada, I. (1973). Experimental archaeology: A new outlook. *American Antiquity* 38(3): 344-350.

Schomburgk, R. H. (1840). Report of the third expedition into the interior of Guayana comprising the journey to the sources of the Essequibo, to the Caruma Mountains, and to Fort San Joaquim, on the Rio Branco, in 1837-38. *Journal of the Royal Geographical Society* 10: 191-247.

Sharp, L. (1969). Steel axes for stoneage Aborigines. In Harding, T. G. (ed.), *Peoples and Cultures of the Pacific*, The Free Press, Glencoe, Ill.

Siskind, J. (1973). Tropical forest hunters and the economy of sex. In Gross, D. (ed.), *People and Cultures of Native South America*, Doubleday-Natural History Press, Garden City, New York, pp. 226-240.

Sonnefeld, J. (1960). Changes in an Eskimo hunting technology, and introduction to implement geography. *Association of American Geographers, Annals* 50(2): 172-186.

Stirling, M. W. (1938). Historical and ethnographical material on the Jívaro Indians. *Bulletin of the Bureau of American Ethnology*, No. 117, Washington, D.C.

Taylor, W. P. (1956). *The White-Tailed Deer of North America.* The Stackpole Co., Harrisburg, Pa., and the Wildlife Management Institute, Washington, D.C.

Townsend, W. (1969). Stone to steel use in New Guinea society. *Ethnology* 8(2): 199-206.

Vickers, W. (1976). *Cultural Adaptations to Amazonian Habitats: The Siona-Secoya of Eastern Ecuador.* PhD thesis, University of Florida, Gainesville.