*Human Ecology, Vol. 16, No. 3, 1988*

# Efficiency and Focus of Blowpipe Hunting among Semaq Beri Hunter-Gatherers of Peninsular Malaysia

**Yukio Kuchikura**[1]

*This paper presents quantitative data on blowpipe hunting among the Semaq Beri, a group of the aboriginal peoples of Peninsular Malaysia, with special reference to daily activity rhythms, space use, efforts, and efficiency of hunting. The role of hunting is examined in the diet of the population studied, which is in transition from a nomadic to a sedentary lifestyle. The special hunting focus on a few species (the leaf monkeys,* Presbytis *spp.) is examined in relation to ecology of prey items and using the optimal diet breadth model. Technological efficiencies of the Semaq Beri blowpipe and dart are compared with the Waorani of Ecuador.*

**KEY WORDS:** Peninsular Malaysia; blowpipe hunting; primate ecology; optimal foraging theory.

## INTRODUCTION

Except for groups who possess shotguns, the blowpipe remains the only hunting weapon among Malayan aboriginal peoples (Orang Asli) after the bow and arrow, the traditional weapon of the Negritos, was completely abandoned over the last 100 years. While the question of weapons change has been discussed from various points of view (Williams-Hunt, 1952; Schebesta, 1954; Endicott, 1969; Rambo, 1978), there are few data on the hunting activity based on direct observation.

There are a number of recent systematic and quantitative studies on hunting activities among native peoples, elucidating ecological relationships

[1]Department of Anthropology, Faculty of General Education, Gifu University, 1-1 Yanagido, Gifu 501-11, Japan.

between human societies and their resource units of wild fauna (Marks, 1977); the comparative analysis of hunting technologies (Hames, 1979; Hayden, 1981; Saffirio and Scaglion, 1982; Ichikawa, 1983); and developing models of the evolution of hunting behavior of hominids (Hill, 1982; Hill and Hawkes, 1983). Blowpipe hunting in this respect has been largely neglected, with the notable exception of a study done by Yost and Kelly (1983) among the native Amazonians.

The purpose of this article is to present quantitative data on the blowpipe hunting of the Semaq Beri, an aboriginal group of Peninsular Malaysia. The daily patterns of hunting activity are described in quantifiable terms. The hunting efforts and efficiency are measured and the relevant factors affecting them are delineated and analyzed. The place of blowpipe hunting in overall meat-procuring strategy of the group studied is analyzed. The problem of prey selection is discussed with the use of a model derived from optimal foraging theory, a theory of increasing interest to anthropologists (Smith, 1983). Finally, the technological efficiency of the blowpipes and darts of the Semaq Beri is compared with those of the Amazonian hunters.

## BACKGROUND

The Semaq Beri, numbering some 1700 persons, are distributed in the coastal and interior parts of Pahan State of Peninsular Malaysia. They belong ethnically to the *Senoi*, one of the three major categories of the Malayan aboriginal people (the Orang Asli). Although most of them have been shifting cultivators or settled agriculturalists, a few groups in the most interior part of Pahan, including the community I studied, lived a nomadic hunting and gathering life until a decade ago. Since the 1960's, the Malaysian government has attempted to induce nomadic communities to live in settlements and take up permanent agriculture. The Semaq Beri community studied responded to the government inducements and in 1977, settled in the present village (Kampong Orang Asli) and gardens within the Orang Asli reservation in Trengganu State (Fig. 1).

Except during the rainy months (November and December), it was rare to find all the villagers living together in the village at any one time. The lagers spent a great deal of time on trips away from the village, including lengthy journeys into the interior areas. These trips, here labeled as "treks," were ordinarily carried out by several families as a unit, ranging in length from 2–36 days with a mean of 10.2 days. The most important purpose of the treks was to collect jungle produce for sale, such as rattan (*Calamus* spp.) and incense wood (*Aquilaria* spp.).

Of the total food energy consumed during the study period, 42.6% came from food purchased in the market or stores, 26.2% from garden crops,

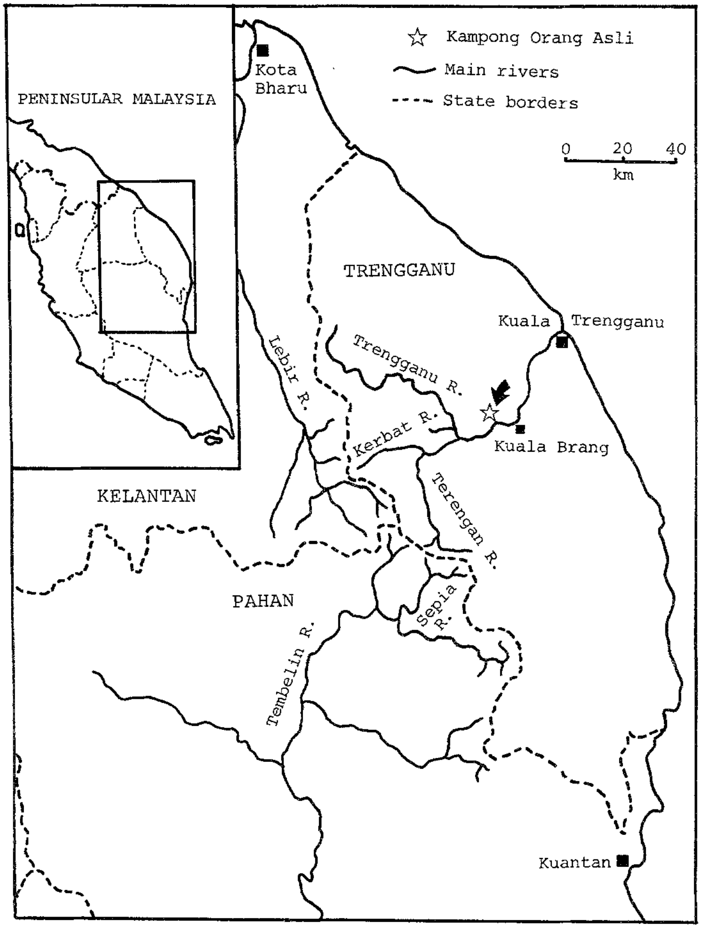



**Fig. 1.** Map of study area.

24.9% from the rations supplied by the government (Jabatan Hal Ehwal Orang Asli, JOA), and 4.5% from wild plants and animals.

On the other hand, the villagers still relied heavily on the wild fauna for their animal food. Beside blowpipe hunting, various kinds of ground-dwelling animals were captured by hand or with machetes, including Burmese brown tortoises (*Testudo emys*), monitors (*Varanus* spp.), reticulated pythons (*Python reticulatus*), Malayan pangolins (*Manis javanica*), and bamboo rats (*Rhyzomys sumatrensis*).

The complex network of streams and rivers formed in the activity areas of the Semaq Beri provides a variety of aquatic resources including fish of various sizes, turtles (*Trionyx cartilagineous*), water tortoises (*Cyclemys dentata*), and frogs (*Rana macrodon*). Many tools and methods were employed to capture these resources depending on the size of the water systems. Blowpipe hunting accounted for 41.5% of the total amount of animal foods consumed; hunting by hand accounted for 12.7%, fishing, 33.7%, while the remaining 12.1% was supplied by purchased foods and the government rations.

The western interior of Trengganu State is composed of mountain areas. The Semaq Beri used the foothills for their activities, never going over 600 m in altitude except when they traveled to Pahan and Kelantan over the higher mountains. The activity areas of the Semaq Beri are covered with lowland tropical rain forest. Most of the area is composed of primary forest, but there is some secondary forest in the vicinity of the abandoned Malay villages along the large rivers.

Extensive logging is now underway in the interior of Trengganu. A broad logging road reaches up to the border between Trengganu and Kelantan, crossing the Ulu Trengganu area from east to west. A vast network of roads extends far into the hills on both sides of the main rivers. The Semaq Beri made full use of the logging roads for traveling and hunting.

The Malay Peninsula has a typical equatorial climate characterized by constantly high temperature, high relative humidity, and high annual rainfall. In Trengganu, the heaviest rainfall is in November, December, and January under the influence of the northeast monsoon. Flooding starts late in November and sometimes extends into January. The 2 or 3 months following the flood season are quite dry. According to meteorological records (1968–1978) in Kuala Brang, the town nearest to the one studied, the annual precipitation reaches nearly 3800 mm, 40% of which occurs in November and December.

## DATA COLLECTION

Blowpipe hunting was practiced both in the forests surrounding the village and in the interior areas where the people camped during the treks. Data on blowpipe hunting were compiled separately according to the two phases of the people's life, one in the village and the other on the treks. The hunts from the village are here labeled as "the hunts in the village area," and those from the camps as "the hunts in the camping areas."

Data on the former were collected in 214 days. From August 1978 to January 1979, records were taken for 140 successive days. In addition, data were collected for 74 days from February to June 1979. Data on the latter were collected on 12 separate treks (120 days).

Forty-three hunts in the village area and 15 hunts in the camping areas were observed. In the course of hunt, the following items were recorded and checked: the duration of hunting; time spent on various activities which constituted the day's hunt, such as searching for game, stalking, and shooting game, waiting for game hit to fall from the tree, retrieving, and butchering the game killed; the kinds of animals encountered; frequency of encounter; the number of darts used; and weight of animals killed.

For the hunts not observed directly, the departure and arrival time of the hunters was clocked, and the animals brought back were weighed. The hunters were interviewed after their arrival with respect to the hunting routes, the kinds of animals encountered, and the number of stalks and successful encounters. The author or a JOA field assistant was always stationed in the village and kept the records.

## HUNTING EQUIPMENT

The blowpipe, made of a kind of bamboo (*Schizostachyum jaculans*), consists of an inner tube and an outer tube. Two internodes of the bamboo are joined to make the inner tube. The outer tube, the function of which is to protect the inner tube, is also composed of two pieces with different lengths. A globe-shaped or coniform mouthpiece made from resin is attached to the end of the inner tube. The blowpipes ranged in length from 170–215 cm, while the bore of the inner tube is constant at about 1.0 cm.

A dart consists of a thin shaft and a coniform plug of pith. The shaft, shaved from a leaf rib of palm, ranges in length from 19–23 cm, and weighs from 0.6–0.8 g. The dart tip is coated with poison, the sap of the *ipoh* tree (*Antiaris toxicaria*). The hunter usually prepares 20–50 darts before going out hunting. Just before shooting, the wadding, a fibrous pulp of rattan leaves, is inserted behind the dart to form a tight airseal in the bore of the blowpipe. Although a great number of variables affect the time it takes for a dart to kill an animal, an adult leaf monkey will typically fall from the trees in 10–30 minutes. Periods from as short as 6 minutes to as long as 80 minutes were observed.

## ACTIVITY PATTERN OF HUNTING

### Organization of Hunting

Although hunting with a blowpipe was essentially an individual activity, a hunting group composed of two or three persons was most common.

A hunting group sometimes included one or two persons, called "carriers," who did not use a blowpipe in hunting and only carried the game killed. The person who actually used a blowpipe in hunting was referred to as "hunter" and distinguished from the "carriers." According to hunters, the main reasons they preferred to go hunting in a group were that they felt less fear of dangerous animals such as tigers, panthers, and elephants, and that the presence of carriers would free the hunters from carrying the game so that they could continue hunting after the first killing.

The blowpipes were employed exclusively by men. Women participated in hunting on rare occasions, taking the part of "carrier." Among the villagers, there were nine adult males referred to as "hunter," all of whom were assumed to be over 30 years old (Table I, individual numbers 1-4 and 7-11). With the increasing emphasis on collecting rattan for subsistence, there was a conspicuous tendency for the younger men to be reluctant to master the techniques for blowpipe hunting. The younger men in their twenties (individual numbers 12-15) and older boys participated in hunting only as "carriers."

Of the various sizes of hunting group, ranging from 1-5, a group consisting of two persons was most frequent, accounting for 49.3% of all the hunting groups, although single hunters accounted for about 25% of the total number of hunts. Groups composed of more than four persons were rarely found.

## Daily Activity Routine and Rhythm

Activities comprising the day's hunt are categorized as follows: traveling to and from hunting grounds, searching for potential game animals, stalking them, shooting darts, waiting for animals shot to fall from the tree, retrieving the carcass, butchering, resting, and engaging in activities other than hunting.

The time budget in the day's hunt is shown in Table II. The total time invested in searching activity in the day's hunt averaged about 140 min both for the hunts in the village area and for those in the camping areas, accounting for 36% and 50% of the total hunting time in the day, respectively. Adding the time spent traveling, it accounted for 56% of the total hunting time in the village area. It should be remarked that the time spent in pursuing (stalking and shooting) in the average hunt accounted for only 12-15% of the total hunting time.

The hunters left the village or camp for hunting during the wide range of hours between 5:00 and 14:00. About 73% of the departures from the village were concentrated between 6:00 and 9:00 in the drier months. The peak hours in the rainy months were delayed by 1 hour. The departures from the camps in the drier months had a bimodal peak between 7:00 and 9:00,

**Table I.** Families, Hunters, and Carriers of the Group Studied

| Family number | Family size | Family composition and age category[a,b] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Sex | 0–2 | 3–9 | 10–14 | 15–24 | 25–54 | 55+ |
| 1 | 2 | M | | | | | | 1(1)[c] |
| | | F | | | | | | 1 |
| 2 | 4 | M | | | 1[d] | | 1(2)[c] | |
| | | F | | 1 | | | 1 | |
| 3 | 4 | M | | 1 | 1[d] | | 1(3)[c] | |
| | | F | | | | | | |
| 4 | 8 | M | 2 | 1 | 1[d] | | 1(4)[c] | |
| | | F | | 1 | 1 | | 1[d] | |
| 5 | 3 | M | | 2 | | | 1(5)[d] | |
| | | F | | | | | | |
| 6 | 4 | M | | | | | 1(6)[d] | |
| | | F | 1 | 1 | | | 1 | |
| 7 | 5 | M | | 3 | | | 1(7)[c] | |
| | | F | | | | | 1 | |
| 8 | 6 | M | | 2 | | | 1(8)[c] | |
| | | F | | 2 | | | 1 | |
| 9 | 4 | M | | | | | 1(9)[c] | |
| | | F | | 1 | 1 | | 1[d] | |
| 10 | 3 | M | | | | | 1(10)[c] | |
| | | F | | | | 1 | 1[d] | |
| 11 | 5 | M | 1 | 1 | | | 1(11)[c] | |
| | | F | 1 | | | | 1 | |
| 12 | 3 | M | | | | 1(12)[d] | | |
| | | F | 1 | | | 1 | | |
| 13 | 3 | M | | | | 1(13)[d] | | |
| | | F | 1 | | | 1[d] | | |
| 14 | 2 | M | | | | 1(14)[d] | | |
| | | F | | | | 1 | | |
| 15 | 2 | M | | | | 1(15)[d] | | |
| | | F | | | | 1 | | |
| 16 | 3 | M | | | 1 | 1[d] | | |
| | | F | | | | | 1 | |

[a]Individual numbers are in parentheses.
[b]The ages of the individuals were based on those registered in the JOA office and my estimation (Kuchikura, 1987, p. 15).
[c]Those who participated in hunting as "hunter."
[d]Those who participated in hunting as "carrier."

and between 12:00 and 14:00, with a higher frequency in the morning than in the afternoon, reflecting the activity pattern in the camps where men were often engaged in collecting rattan in the morning hours and went out hunting after lunch. As with the hunts from the village, the peak hours of the departures from the camps were delayed by 1 hour in the rainy months.

The normal pattern of blowpipe hunting was to leave in the early morning and return to the village or camp before dark. If hunters succeed in kill-

**Table II.** Average Time Budget of the Day's Hunt

| Activity | Village area ($n$ = 43) Minutes | Village area ($n$ = 43) Percent | Camping areas ($n$ = 15) Minutes | Camping areas ($n$ = 15) Percent |
|---|---|---|---|---|
| Travelling[a] | 78 | 20.4 | – | – |
| Searching[b] | 139 | 36.4 | 137 | 50.3 |
| Stalking/shooting[c] | 56 | 14.6 | 33 | 12.1 |
| Waiting[d] | 31 | 8.0 | 22 | 8.1 |
| Retrieving[e] | 3 | 0.7 | 1 | 0.4 |
| Butchering[f] | 16 | 4.0 | 13 | 4.8 |
| Resting | 32 | 8.3 | 22 | 8.1 |
| Other activities[g] | 29 | 7.7 | 44 | 16.2 |
| Total | 384 | 100.0 | 272 | 100.0 |

[a]When the hunters went out hunting from the village, they frequently used the main logging road and paths on the plantations to go to the remote hunting grounds.
[b]While walking slowly in the forest, a hunter concentrates his attention on a noise in a tree or trembling leaves or sticks to locate the potential game.
[c]If an animal making a noise is worth a shot, the hunter then tries to approach it stealthily as close as possible.
[d]If the hunter is sure that the darts hit the animal, he will wait for the animal to fall from the tree.
[e]Upon hearing the flop of a falling dead animal, the hunter goes in the direction of the noise and collects the carcass.
[f]The animal about the size of an adult monkey is usually butchered in the forest for convenience of transportation.
[g]In the course of hunting, the hunter sometimes engages in various activities, such as fishing, pursuing ground-dwelling animals, digging wild yams, and collecting incense wood or medicinal herbs, if an opportunity arises.

ing sufficient game, normally two or three leaf monkeys, within the morning hours, they may leave for home under a high sun. "Sufficient" game, defined as the weight which a person does not hesitate to carry from the hunting spot to the village or camp, may vary with the number of persons in the hunting group. A hunter who hunts alone will stop hunting after shooting down two leaf monkeys, whereas a hunting group composed of more than two persons may continue to hunt even after killing four leaf monkeys until just enough time is left to return to the village or camp.

When the hunters continued to hunt in the remote hunting grounds without killing any animal, they sometimes arrived home well after dark (around 20:00). The peak hours of arrival in the drier months were between 17:00 and 18:00 in the village, and between 15:00 and 17:00 in the camps. The peak hours were delayed by 1 hour in the rainy months, corresponding to the delay in departure time mentioned earlier.

The hours spent in the day's hunt varied considerably, ranging from less than 1 hour to more than 13 hours. The hunts in the village areas averaged 7.67 hours in the drier months and 7.88 hours in the rainy months. The hunts in the camping areas were in general shorter than those in the village area, averaging 5.07 hours in the drier months and 6.98 hours in the rainy months. The tendency for the hunts in the camping areas to become much shorter in the drier months was related to the intensification of rattan collection.

Because the hunters focused particularly on the two species of leaf monkey (dusky leaf monkey, *Presbytis obscura* and banded leaf monkey, *P. melalophos*), it is very likely that they adjusted their daily hunting activity to the ecology of the leaf monkeys.

According to Curtin (1980, pp. 139-140), the two leaf monkey species have two intensive feeding periods a day, one in the morning hours and another in the afternoon. In the case of the dusky leaf monkey, there is a morning feeding period betwen 7:00 to 10:00. After a mid-day lull from 10:00 to 14:00, feeding becomes active again from 14:00 to 18:00 with a peak between 14:00 and 15:00. The banded leaf monkey has a morning feeding peak from 7:00 to 12:00 with the most intensive feeding of the day between 8:00 and 10:00. Afternoon feeding for the banded leaf monkey lasts from 15:00 to 19:00.

Figure 2 shows the hourly fluctuations of frequency with which the hunters encountered the leaf monkeys. The ratio of encounter is here defined as the percentage of the total number of encounters in a given hour to the total number of individual hunters or hunting groups present in the hunting grounds in that hour. The daily pattern of encounter is assumed to be significantly related to the feeding rhythms of the leaf monkeys. The encounter ratios show a bimodal distribution with one peak between 7:00 and 10:00 and another between 14:00 and 16:00. There was a significant difference in frequency of encounter with the leaf monkeys between the intensive feeding

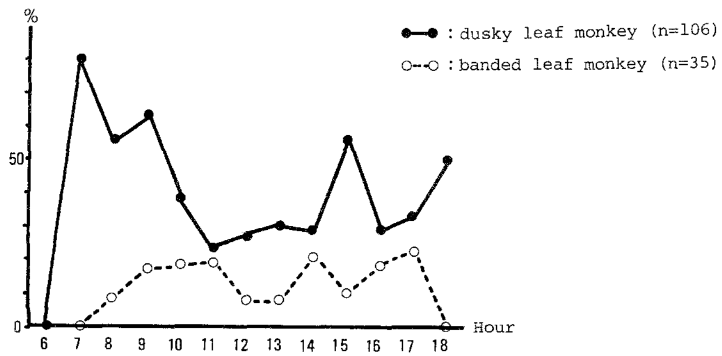
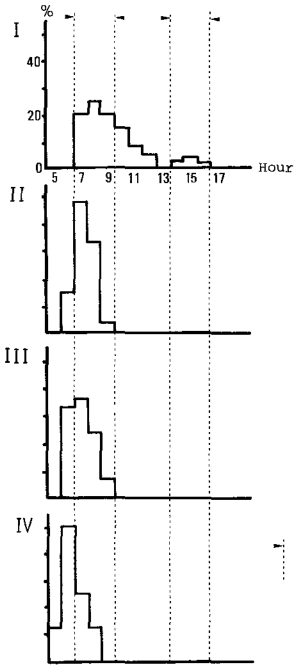



**Fig. 2.** Daily pattern of encounter with the leaf monkeys. The frequency curve indicates the ratios of encounter at intervals of 1 hour for 43 hunts accompanied in the village area.




Intensive feeding period of the leaf monkeys

| | Hunting grounds (see below) | Time required for traveling to the hunting grounds (min) |
|---|---|---|
| I | G1, G2, G3 (n=101) | 0 |
| II | G5, G8 (n=27) | 45 |
| III | G7, G10, G11, G12 (n=44) | 60 - 90 |
| IV | G6, G9, G13 (n=16) | 120 |

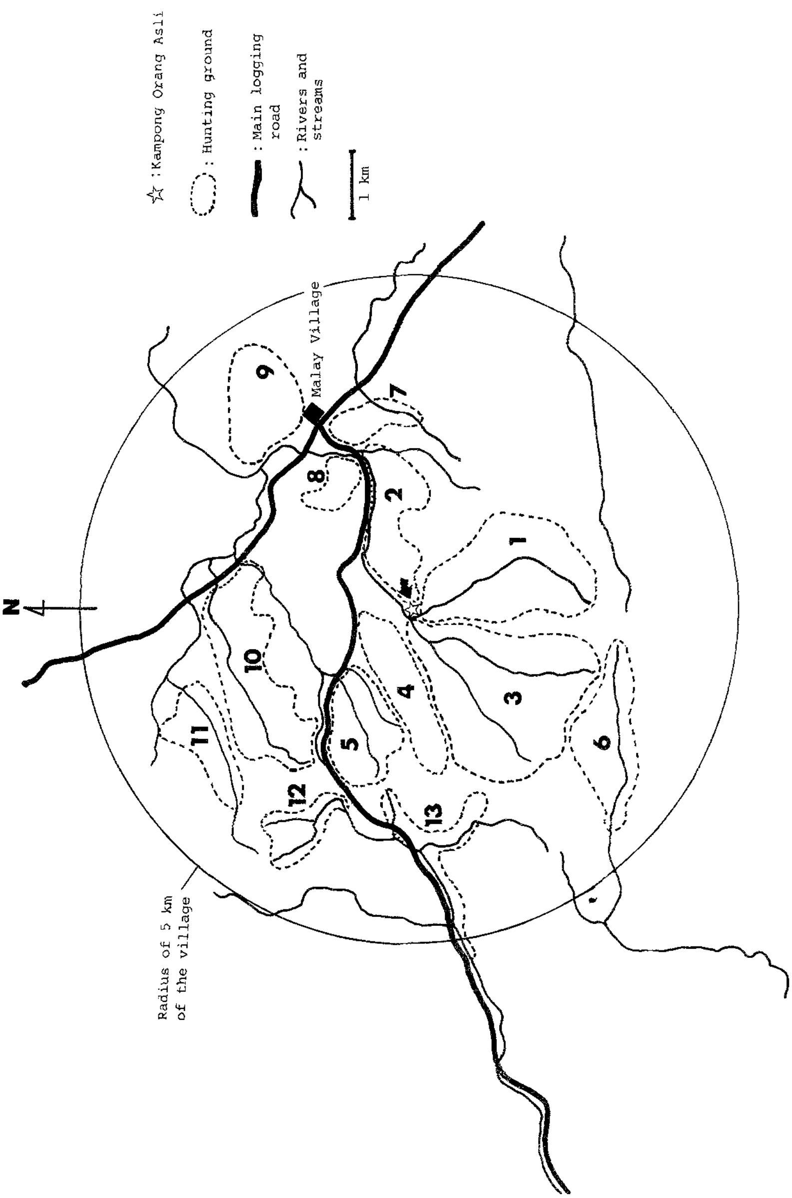



**Fig. 3.** Relationship between departure time and distance of hunting ground. The histograms express the percent distribution of departure at intervals of 1 hour for 188 hunts in the village area.

hours (between 7:00 and 10:00, and between 14:00 and 16:00) and the other hours ($\chi^2 = 18.636$, $p < 0.005$).

According to the hunters, it is when the leaf monkeys are feeding intensively that they are located with the highest frequency and approached with the least difficulty. While intensively feeding, dusky leaf monkeys are dispersed in small subgroups, covering a rather extensive area, and they gather into larger groups when resting during mid-day from 10:00 to 14:00. It is very likely that the hunters will encounter the monkeys with higher frequency when the latter are spread widely in the forest than when they are concentrated in a few unpredictable places. The diurnal dynamics of the group composition of the monkey is also reflected in the lower encounter ratios in the hours between 11:00 and 14:00. The period of time corresponds with the mid-day lull in feeding, in which the monkeys are resting in large groups. Another likely reason why the feeding monkeys are easy to locate is related to the hunter's searching pattern. The hunters mainly depend upon hearing to locate the animals in the dense canopy of the forest, so that the monkeys, which make rather large noises while feeding, are easily located compared to animals sitting silently in the trees.

The hunters are assumed to have adjusted the time of departure to the feeding hours of the leaf monkeys. This is suggested by the relationship between the time of departure and the distance between the village and the hunting grounds (Fig. 3). In the hunts which took place in the closest zone (I), the hunters usually left the village within the morning feeding hours of the leaf monkeys. When the hunters went out to the intermediate zones (II and III) and the farthest zone (IV), they advanced their departures by 1 and 2 hours, respectively. That is, the farther the hunting ground, the earlier in the morning the hunters left the village in order to be at the hunting grounds in time for the intensive feeding hours. Similarly, the hunters often left for the hunting grounds in the vicinity of the village or camps to be in time for the afternoon feeding of the monkeys.

## Encounter with Animals and Frequency of Killing

In the 58 hunts observed both in the village area and in the camping areas, there were 332 instances in which the hunters located animals or heard stirs or noises made by the animals (Table III). Of the total instances, 207 or 62.3% were the encounters with groups or solitary individuals of the monkeys and gibbons (the leaf monkeys, long-tailed and pig-tailed macaques, *Macaca fascicularis* and *M. nemestrina,* and white-handed gibbon, *Hylobates lar*), and 43 or 13.0% were those with diurnal squirrels of various sizes. Nocturnal flying squirrels, rather common in the Malay Peninsula, were never seen during the hunts.

On a few occasions, we came across forest-dwelling ungulates in the course of hunt, including mouse deers (*Tragulus* spp.), Indian muntjac (*Muntiacus muntjak*), wild pig (*Sus scrofa*), tapir (*Tapirus indicus*), and elephant (*Elephas maximus*). The encounters with these animals were by mere chance because the hunters had no intention of searching for and hunting them with blowpipe and darts. While the hunters chased indian muntjacs and pangolins with a machete, the encounters with large mammals, such as wild pig, tapir, and elephant, rather frightened them away.

Among the rustling sounds or noises identified as ones made by animals, the hunters failed to determine which species produced the sounds in 31 instances. In nine instances, they sneaked up to the direction of the sound without succeeding in locating the animal. Judging from the volume of the sounds, most of the unidentified sounds were likely to be produced by smaller animals, such as small-sized tree and ground squirrels, rats, and mice.

In 129 out of the total number of encounters with the monkeys and the gibbons (207), the hunters attempted to stalk them. On the remaining 78 instances (37.7%), they immediately gave up stalking. According to the hunters, the reasons why the encounters with the animals did not lead to stalking were as follows: (1) the animals located were too far away to approach (on 35 instances or 44.9% of the total instances on which the hunters gave up stalking), (2) the animals were traveling to feeding places (32 instances or 41.0%), and (3) the animals immediately noticed the presence of the hunters and disappeared (11 instances or 14.1%). According to the hunters, the monkeys traveling are difficult to pursue.

The monkeys and gibbons frequently noticed the hunters approaching and ran away before they took a shot. Thirty-five or 27.1% out of the 129 stalking attempts ended in failure. Forty-five or 47.9% out of the 94 shooting attempts were in vain, that is, no dart hit the animals. On the remaining 49 shooting incidents, 97 monkeys and gibbons were hit. This means that, on average, two animals were hit in each shooting incident. The hunters let 59 monkeys or gibbons escape owing to insufficient potency of the poison. Sixty-one percent of the animals hit did not fall from the trees and disappeared.

In only 24 (11.6%) of the 207 encounters with the monkeys and gibbons, did the hunters manage to kill at least one animal. A total of 530 darts were used in the 94 shootings. On average, 5.5 darts were required to hit a monkey or gibbon and 13.9 darts to kill it.

Two species of large-sized squirrels, *Ratufa bicolor* and *R. affinis,* were located in nine instances. On encountering these squirrels, the hunters always tried to stalk and shoot them in earnest. In two instances, they succeeded in hitting and killing the animals. Among squrrels of various sizes, such small species as *Sundasciurus* spp., weighing less than 100 g, were found with the highest frequency, but they were ignored by the hunters except on two

**Table III.** Frequency of Encounter with Animals and Kill in Hunting

| Animal species | Number of en-counters | Number of stalks | Number of shooting instances | Number of successful instances in hitting[a] | Number of succesful instances in killing[a] | Total number of darts used |
|---|---|---|---|---|---|---|
| A. Village area (43 hunts, 99.8 hours observed, 165.4 km covered) | | | | | | |
| Dusky leaf monkey | 106 | 66 | 46 | 25(54) | 13(21) | 260 |
| Banded leaf monkey | 35 | 25 | 21 | 13(22) | 6 (8) | 119 |
| Long-tailed macaque | 8 | 3 | 2 | 1 (1) | – | 11 |
| Pig-tailed macaque | 6 | 4 | 3 | 2 (2) | – | 16 |
| White-handed gibbon | 7 | 4 | 3 | 1 (1) | – | 8 |
| Subtotal for primates | 162 | 102 | 75 | 42(80) | 19(29) | 414 |
| Large-sized squirrels[b] | 6 | 5 | 4 | 2 | 2 | 7 |
| Middle-sized squirrels[c] | 10 | 5 | 2 | – | – | 11 |
| Small-sized squirrels[d] | 15 | 2 | 2 | 1 | 1 | 5 |
| Large-sized birds[e] | 7 | 1 | – | – | – | – |
| Middle-sized birds[e] | 6 | 1 | – | – | – | – |
| Small-sized birds[e] | 6 | 1 | 1 | 1 | 1 | 8 |
| Phasianids[f] | 2 | – | – | – | – | – |
| Musang or Civets[g] | 3 | 2 | 2 | 1 | – | 9 |
| Bats | 2 | | – | – | – | – |
| Wild pig | 2 | – | – | – | – | – |
| Indian muntjac | 1 | 1[h] | – | – | – | – |
| Mouse deer | 1 | – | – | – | – | – |
| Tapir | 1 | – | – | – | – | – |
| Pangolin | 1 | 1[h] | – | – | – | – |
| Elephant[i] | 1 | – | – | – | – | – |
| Felids[i] | 2 | – | – | – | – | – |
| Unidentified | 22 | 7 | – | – | – | – |
| B. Camping areas (15 hunts, 31.8 hours, 61.0 km) | | | | | | |
| Dusky leaf monkey | 27 | 15 | 10 | 4(13) | 2 (6) | 65 |
| Banded leaf monkey | 8 | 8 | 6 | 2 (2) | 1 (1) | 34 |
| Long-tailed macaque | 4 | 2 | 1 | 1 (1) | 1 (1) | 5 |
| Pig-tailed macaque | 1 | 1 | 1 | – | – | 9 |
| White-handed gibbon | 5 | 1 | 1 | 1 (1) | 1 (1) | 3 |
| Subtotal for primates | 45 | 27 | 19 | 7(17) | 5 (9) | 116 |
| Large-sized squirrels | 3 | 1 | 1 | – | – | 1 |
| Middle-sized squirrels | 4 | 3 | 1 | – | – | 1 |
| Small-sized squirrels | 5 | 1 | – | – | – | – |
| Large-sized birds | 3 | – | – | – | – | – |
| Middle-sized birds | 3 | – | – | – | – | – |
| Small-sized birds | 5 | – | – | – | – | – |
| Phasianids | 1 | – | – | – | – | – |
| Civets | 2 | 2 | 1 | 1 (1) | 1 (1) | 4 |

**Table III.** Continued.

| Animal species | Number of en-counters | Number of stalks | Number of shooting instances | Number of successful instances in hitting | Number of succesful instances in killing | Total number of darts used |
|---|---|---|---|---|---|---|
| Indian muntjac | 1 | – | – | – | – | – |
| Felids | 1 | – | – | – | – | – |
| Unidentified | 9 | 2 | – | – | – | – |

[a]Number of animals hit or killed in parentheses.
[b]*Ratufa* spp., weighing 1.0–1.5 kg.
[c]*Callosciurus* spp., weighing 200–500 g.
[d]*Sundasciurus* spp., weighing 50–100 g.
[e]Counted here as "encounter" were the cases in which the figures of birds or their calls were seen or heard at relatively close range, within 30–40 m. The birds flying or soaring in the sky and those of which songs or calls were heard from far away were ignored. Large-sized birds: hornbills, middle-sized birds: pigeons, doves, and parrots, and small-sized birds: passerine birds of less than 100 g.
[f]Pheasants and jungle fowl.
[g]*Viverra* spp. and *Arctis binturong*.
[h]The hunters chased them to catch by hand or to knock down with a machete.
[i]The noises made by elephants and the roars of tigers (*Panthera tigris*) or leopards (*P. pardus*) were regarded here as "encounter" even if their figures were not located.

occasions when the hunters took shots just for fun. On encountering middle-sized squirrels weighing 200–500g, such as *Callosciurus* spp., the hunters did try to pursue them, but less eagerly than the primates and the large-size squirrels. When prey of such size fled after the first shot, the hunters never gave chase.

Although more frequently seen in flight, hornbills, weighing more than 2 kg, were spotted sitting in the canopy on ten occasions. However, there was no chance of taking a shot because the birds were out of the effective range of the blowpipe. While spotted at close range, middle-sized birds, such as pigeons, doves, and parrots, always fled before the hunter found a good shooting position. It seemed that the hunters were less cautious in pursuing the birds than the monkeys and gibbons. The hunters seemed to hesitate in taking shots at larger birds, because the darts are too light to instantaneously kill larger birds, and they fly away before the dart poison takes effect.

## EFFORT, RETURN, AND EFFICIENCY OF HUNTING

### Frequency of Hunting

For 214 observation days, the nine hunters mentioned above spent 1476 days in the village, of which 249 were hunting days. On the average day in the village, there were six or seven hunters, of whom one or two went out hunting. A hunter, in other words, spent an average of one out of five to six days hunting. On the other hand, the hunters spent 635 days camping on 120 observation days during the treks, of which 117 were hunting days. That is, there were 5.3 hunters in the average camp, and 1.0 hunters went out hunting. There was no significant difference in frequency of hunting, expressed by the percentage of hunters out hunting to the total number of hunters present for a given period, between the village and the treks ($\chi^2$ = 0.917, $p > 0.30$).

In the village, the frequency of hunts fluctuated greatly over months, averaging 16.9%. Although frequency of hunts was constantly at the 17–18% level between September and November, this doubled in December and January, and suddenly dropped to nearly zero in February, with the lowest frequency continuing until July.

Frequency of hunts varied greatly among the treks, ranging from 0.0% in Treks 5 and 17 to 81.0% in Treks 7 and 8 with a mean of 18.4%. The location of camp was a main factor affecting frequency of hunting on the treks; the lower hunting rates were associated with the treks along the larger rivers that were good for fishing, and the higher ones with the treks on which no good river for fishing was found around the camps. The relationship between frequency of hunting and location of camp will be examined in detail in the following section.

## Hunting Return and Efficiency

Of 188 hunts which took place in the village area during the study period, 80 were successful; that is, some prey was killed. The average success rate, defined here as the percentage of successful hunts to the total number of hunts, was 42.6%. At least one animal was brought into the village on 59 (62.1%) out of 95 days on which hunts took place. Table IV shows that 813.3 kg of animals in live weight were killed in the 188 hunts in which a total of 249 hunters participated and spent 1974.9 hours. The mean yield per hunt was 4.33 kg in live weight. The return per hunter per day was 3.27 kg on average, and 1 hour of hunting yielded an average of 0.41 kg.

Of 92 hunts in the camping areas, 30 or 32.6% were successful, and the people obtained meat on 23 or 48.9% out of 47 hunting days. An average hunt produced 3.60 kg, and the average hunter yielded 2.8 kg per day with an input–output ratio of 0.50 kg/hunter/hour.

The amount of variance in return was very large for the individual hunts both in the village area and in the camping areas, ranging from 0.0–31.5 kg and from 0.0–21.5 kg, respectively. There were also considerable fluctuations in the total amount of meat brought back on a hunting day, ranging

**Table IV.** Animal Species Killed in Blowpipe Hunting

| | | Village area | | Camping areas | |
|---|---|---|---|---|---|
| Species | English name | Number | Weight (kg) | Number | Weight (kg) |
| *Presbytis obscura* | Dusky leaf monkey | 97 | 597.5 | 39 | 271.8 |
| *Presbytis melalophos* | Banded leaf monkey | 25 | 138.8 | 5 | 29.5 |
| *Hylobates lar* | White-handed gibbon | 3 | 20.6 | 5 | 22.8 |
| *Macaca fascicularis* | Long-tailed macaque | 3 | 18.9 | | |
| *Macaca nemestrina* | Pig-tailed macaque | 2 | 19.6 | | |
| *Arctis binturong* | Binturong | 1 | 10.4 | 1 | 7.4 |
| *Ratufa bicolor* | Black giant squirrel | 2 | 3.2 | | |
| *Ratufa affinis* | Cream-colored giant squirrel | 1 | 1.3 | | |
| *Rhinoplax vigil* | Helmeted hornbill | 1 | 3.0 | | |
| Total | | 135 | 813.3 | 50 | 331.5 |

from 0.0–70.9 kg with the mean of 8.6 kg in the village and from 0.0–30.5 kg with the mean of 7.1 kg for the camps.

In the village, there was a significant correlation between the total number of hours spent in hunting and the total amount of game killed on that day ($r = 0.546, p < 0.01$). In this respect, daily return is a function of labor input; that is, the more man-hours invested, the more meat the community was likely to obtain. On the other hand, there was no such correlation on the treks ($r = -0.015$). This is partly because the data were gathered from the various camps. The variation in daily return, therefore, might be a simple reflection of differences in the environmental conditions such as quantity of game. Another relevant factor is the lower predictability of the foraging routes of the monkeys in the camping areas as compared with the village area, which might account for the lower rate of encounters with the monkeys. This, in turn, might be reflected in the lower success rate in the camping areas (32.6% for the camping areas and 42.6% for the village area). In spite of the lower success rate, the hourly return rate of the hunts in the camping areas was higher than that in the village area. This is mainly due to the fact that the average duration of a day's hunt was much shorter in the camping areas than in the village area.

Table V shows the variation in individual efforts and return among the hunters in the village. There were great variations of frequency of hunting,

**Table V.** Individual Variation of Hunting Effort and Returns for the Hunts in the Village Area

| Individual number | Number of days observed[a] | Frequency of hunting (%) | Success rate (%) | Total amount of catch (kg) | Daily return rate (kg/ hunting day) |
|---|---|---|---|---|---|
| 1 | 177 | 5.6 | 0.0 | 0.0 | 0.00 |
| 2 | 144 | 15.7 | 13.6 | 30.7 | 1.40 |
| 3 | 176 | 24.4 | 32.6 | 114.3 | 2.66 |
| 4 | 171 | 20.5 | 57.1 | 257.0 | 7.34 |
| 7 | 52 | 11.5 | 0.0 | 0.0 | 0.00 |
| 8 | 193 | 15.5 | 33.3 | 94.4 | 3.15 |
| 9 | 194 | 16.5 | 40.6 | 129.0 | 4.03 |
| 10 | 195 | 21.5 | 31.0 | 120.6 | 2.87 |
| 11 | 178 | 14.6 | 30.8 | 67.3 | 2.59 |

[a]The total number of observation days in the village was 214 dyas.

success rate, and return rate among the hunters. There was a significant correlation between frequency of hunting and success rate ($r_s = 0.658, p < 0.05$, one-tailed). The tendency for hunters with higher success rates to hunt more frequently produced great variation in amount of catch among the hunters. The amount of catch significantly correlated with the frequency of hunting ($r_s = 0.792, p < 0.01$, one-tailed). In the village, the most successful hunter (individual number 4) brought back 32% of the total catches in weight, or he and the next most successful hunter (individual number 9) together accounted for nearly half of the total catches.

## The Place of Blowpipe Hunting in Meat-Procuring Strategy

About 90% of the total energy intake in the Semaq Beri diet was from plant food, while 53% of protein intake was of animal origin. The animals hunted with blowpipe provided 4.0% of the total amount of energy and 21.1% of protein during the study period. The Semaq Beri obtained animal food through five means: blowpipe hunting, hunting by hand, fishing, purchase, and the rations supplied by the government (JOA).

The proportions in which the five food sources contributed to the intake of animal food changed greatly in accordance with seasons and locations (Fig. 4). There was no food source which constantly supplied a significant amount of animal food throughout the year and throughout the area. The people had to adjust their nutritional demands to the irregularities and the inconsistencies of the sources. Which sources and the extent to which the people depended upon them were mainly determined by two factors: availability and ease of acquisition.

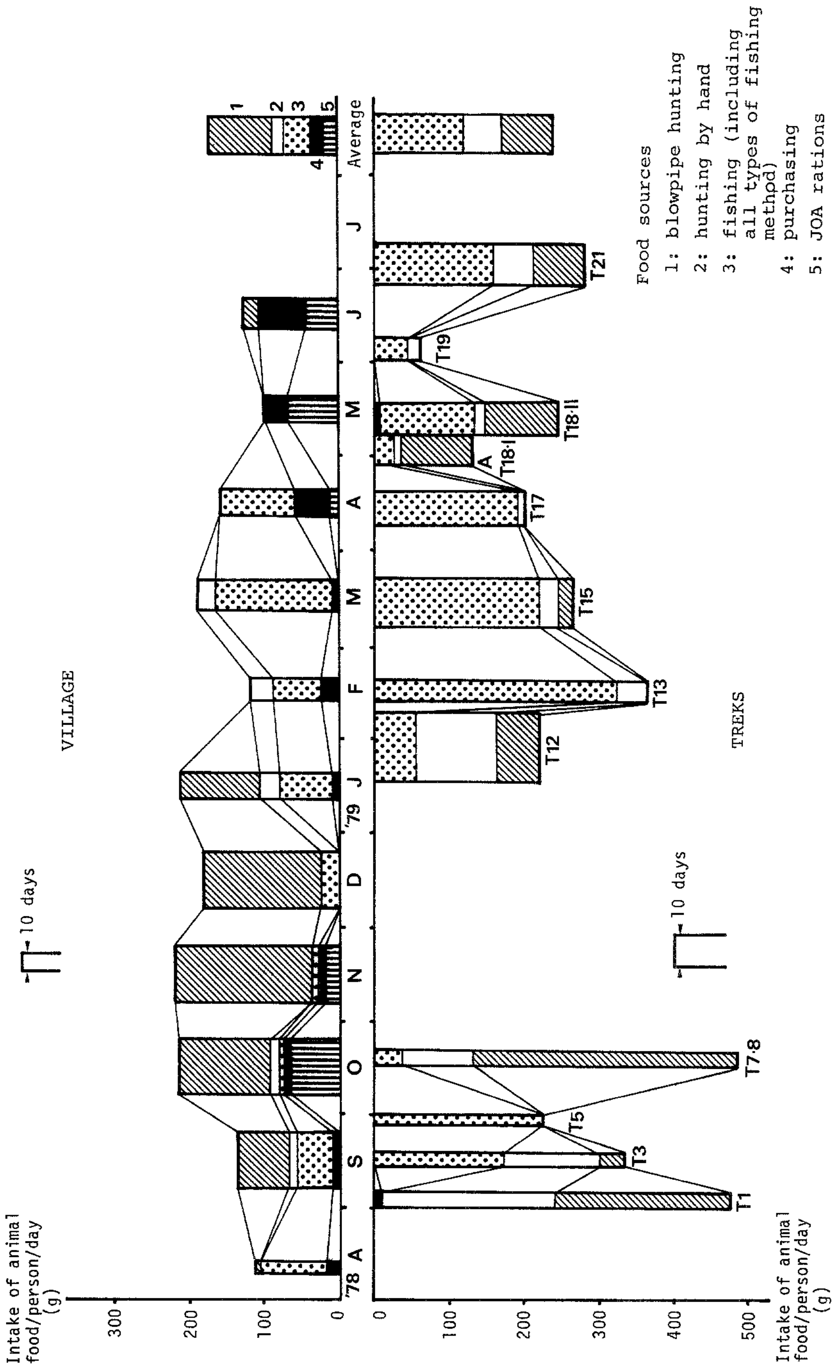



**Fig. 4.** Variation of animal food intake and contributions of the five food sources. The average per-capita intake is adjusted to a single adult male by applying man-value coefficients for food consumption (Kuchikura, 1987). The breadth of the rectangles shows the number of days of observation.

The meat supply through hunting by hand was quite irregular because the hunting was of a casual sort, and because the animal species pursued, in particular, the Burmese brown tortoises which accounted for 76% of the total catches, were unevenly distributed in the forest. Owing to past human predation, the tortoise was scarce in the vicinity of the village but abundant in the relatively undisturbed interior parts. On several treks, the animals captured in the hunting provided 40–50% of the total amount of animal food consumed during the treks.

The availability of purchased food varied with the amount of money being earned through collecting rattan. In the purchase of food, the people always gave staple foods, such as rice and wheat flour, priority over animal foods, such as tinned and raw fish; they bought animal foods only when there was some money left after the purchase of staple foods. After April, when they could afford to buy animal foods because of increasing opportunities for collecting rattan, the purchased food gained in importance, accounting for 30–50% of the animal food consumed in the village.

The JOA rations, although obtainable with the least effort (practically zero), were less reliable. Animal foods, mainly consisting of salted and tinned fish, were not always contained in the rations, and the amount was not fixed. The supply was interrupted by the floods during the rainy months. The rations, on the other hand, contributed 30–70% of the total amount of animal food consumed in the village in the drier months.

It was rare that either purchased animal foods or those contained in the JOA rations were consumed during the treks. Wild animal food resources were obtainable more easily in the camping areas than in the village area; the people therefore preferred seeking animal foods near the camps to bringing them from the village.

The people favored these three food sources over the food sources exploited by blowpipe hunting and fishing, because the former were obtainable with less effort. The intensity of exploitation of the latter in the village area was alleviated in the drier months when the purchased foods and/or the JOA rations were available in plenty.

However, as compared with the three food sources, the food sources exploited by blowpipe hunting and fishing were more reliable and predictable, together accounting for 73.4% of the total amount of animal food consumed in the village, and 78.5% on the treks. The Semaq Beri adult males allocate their efforts between the two alternatives from two perspectives: efficiency (return rate) and stability of catch. According to optimal foraging theory (Smith, 1983, pp. 633-634), optimal foragers preferentially allocate foraging time to alternatives with higher return rates. Stability or security in food procurement, on the other hand, is pointed out as being of equal or more importance in people's procurement decisions in some situations (Jochim, 1981, p. 90). Stability of catch is here represented in quantitative terms by the success rate defined in the earlier section (in the case of fishing it is expressed by the proportion of successful fishing instances to the total number of fishing instances).

In the village, the adult males invested more than double the time to blowpipe hunting than they did to fishing on a year-round basis (Table VIA). The average return rate was much higher in blowpipe hunting than in fishing. On the other hand, there was no significant difference in success rate between them (42.5% for blowpipe hunting and 52.6% for fishing; $\chi^2$ = 2.228, $0.10 < p < 0.25$; Table VII); that is, there was no significant difference in stability of catch between the two activities in the village area. The adult males are assumed to have allocated preferentially their time to blowpipe hunting in the village except the hottest months (February to June) because of its higher return rate and relatively high stability of catch.

The time allocation in the village during the hottest months cannot be determined only by these two criteria, since the adult males neglected blowpipe hunting and allocated considerable time to fishing. It could not be confirmed in quantitative terms that blowpipe hunting might actually have become less efficient in these months, when only six hunts were observed in the village. The neglect of blowpipe hunting in the hottest months was most likely related to increasing availability of purchased food in the village. Another likely reason was the strong sunlight during these months. In traveling to and from hunting grounds and searching for game, the hunters made full use of the main logging road, the paths in the oil palm plantations, and abandoned foresting roads where they had to expose themselves to the sun. They dislike working under strong sunlight because it is believed to cause various diseases.

On the other hand, they spent considerable time in fishing during the hottest months in spite of the lower return rate and instability of catch. They frequently fished while diving in the rivers and streams near the village in order to "cool the bodies" heated by the strong sunlight, despite the fact that aquatic resources had been depleted there. Catch was of secondary consideration on these fishing occasions, which evidently lowered the average return rate and success rate. Fishing expeditions to rivers far away from the village were organized on several occasions, corresponding to the season in which the Malayan mud turtles, solitary in other seasons, gather in specific places to mate. Although a large amount of meat was obtained on one expedition (nearly 35 kg in edible weight), the average hourly return rate was relatively low (0.18 edible kg/hr) because the fishing parties were composed of a large number of persons (up to 12) and much time was required for traveling to and from the fishing spots.

On the treks, the adult males allocated the greater part of time available to exploitation of wild animal resources to fishing whenever they found good rivers or streams near the camps (Table VIB). The only exceptional

**Table VI.** Comparison of Efforts and Return Rate between Blowpipe Hunting and Fishing

| Month | Number of days observed | Blowpipe hunting | | | Fishing | | |
|---|---|---|---|---|---|---|---|
| | | Time spent[b] (min) | Catch[c] (kg) | Return rate[d] (kg/hr) | Time spent[b] (min) | Catch[c] (kg) | Return rate[e] (kg/hr) |
| A. Village area | | | | | | | |
| 1978 | | | | | | | |
| Aug. | 5 | 48 | 1.1 | 0.04 | 33 | 17.1 | 0.29 |
| Sept. | 30 | 85 | 56.4 | 0.24 | 21 | 32.4 | 0.31 |
| Oct. | 31 | 67 | 100.2 | 0.32 | 3 | 4.9 | 0.23 |
| Nov. | 30 | 89 | 158.0 | 0.56 | – | – | – |
| Dec. | 31 | 189 | 144.0 | 0.21 | 6 | 0.0 | 0.00 |
| 1979 | | | | | | | |
| Jan. | 14 | 187 | 61.1 | 0.16 | 108 | 39.8 | 0.10 |
| Feb. | 12 | 2 | 0.0 | 0.00 | 65 | 24.4 | 0.13 |
| Mar. | 15 | 4 | 0.0 | 0.00 | 90 | 55.1 | 0.15 |
| Apr. | 15 | – | – | – | 74 | 48.9 | 0.14 |
| May | 14 | 5 | 0.0 | 0.00 | 2 | 0.0 | 0.00 |
| Jun. | 17 | 9 | 7.9 | 0.94 | – | – | – |
| Total/average | 214 | 74 | 528.7 | 0.27 | 34 | 222.6 | 0.15 |

| Trek number | Date | Days | | | | | | |
|---|---|---|---|---|---|---|---|---|
| B. Trek (camping areas) | | | | | | | | |
| 1 | Sep. 1 - Sep. 5 | 5 | 62 | 9.6 | 0.58 | — | — | — |
| 3 | Sept. 14 - Sep. 18 | 5 | 133[f] | 2.2 | 0.08 | 28 | 6.6 | 0.32 |
| 5 | Sep. 26 - Sep. 29 | 4 | — | — | — | 28 | 9.6 | 0.56 |
| 7/8 | Oct. 17-18 - Oct. 22-24 | 5 | 172 | 56.9 | 1.14 | 2 | 0.0 | 0.00 |
| 12[g] | Jan. 15 - Feb. 8 | 25 | 149 | 47.8 | 0.13 | 35 | 19.6 | 0.11 |
| 13[g] | Feb. 11 - Feb. 18 | 8 | 8 | 0.0 | 0.00 | 36 | 29.6 | 0.46 |
| 15[g] | Mar. 6 - Mar. 21 | 16 | 19 | 9.0 | 0.25 | 65 | 89.9 | 0.38 |
| 17[g] | Apr.7 - Apr. 16 | 10 | — | — | — | 77 | 55.6 | 0.38 |
| 18-1 | Apr. 26 - May 6 | 10 | 45 | 43.1 | 0.86 | 8 | 5.7 | 0.12 |
| 18-11[g] | May 7 - May 16 | 11 | 22 | 20.5 | 0.45 | 97 | 27.2 | 0.31 |
| 19 | May 31 - Jun. 6 | 7 | 38 | 2.1 | 0.08 | — | — | — |
| 21[g] | Jun. 24 - Jul. 7 | 14 | 20 | 24.1 | 0.77 | 52 | 54.3 | 0.38 |
| Total/average | | 120 | 60 | 215.3 | 0.32 | 42 | 298.1 | 0.33 |

[a]Of the various kinds of fishing activity (Kuchikura, 1987, pp. 39-47), two are compared here with blowpipe hunting: spearing for fish and fishing for turtles and water tortoises. These fishing activities were carried out exclusively by men, together accounting for 90% in weight of aquatic resources exploited. Other kinds of fishing activities, such as rod-line fishing and poisoning, are here left out of consideration, because they were rarely done by adult males and were not likely to be competitors against blowpipe hunting in the meat-procurement decisions of the adult males.

[b]Time spent by an adult male a day.

[c]Edible weight.

[d]Edible weight produced by a hunter in 1 hour of hunting (carriers are ignored in the calculation).

[e]Edible weight produced by a person in 1 hour of fishing.

[f]A considerable part of the time was spent in searching and collecting incense wood.

[g]The treks proceeded along the large rivers.

case was found on Trek 12 on which more time was spent in blowpipe hunting than in fishing in spite of the fact that they moved the camps along the large rivers. This anomalous time allocation was due to the fact that the water was too high for fishing.

The success rate on the treks was significantly higher in fishing than in blowpipe hunting (32.6% for blowpipe hunting and 86.1% for fishing; $\chi^2 = 57.791$, $p < 0.005$, Table VII), while there was no difference in the average return rate between the activities. The higher stability of catch in fishing provides the reason why fishing was preferred to blowpipe hunting wherever fishing was possible. Blowpipe hunting, if successful, provided larger amounts of meat than fishing (7.2 kg of edible meat/successful hunt vs. 3.4 kg/successful fishing instance), but this occurred only on a small number of occasions. On the other hand, a constant meat supply was possible through fishing, while the amount was smaller. Since campsites were chosen according to the abundance of rattan in the area, the people sometimes set up the camps in places where they found no good river or stream for fishing. In such places, they switched their efforts for meat-procurement from fishing to blowpipe hunting (Treks 1, 3, 7, 8, 18-I, and 19).

In conclusion, there was a tendency for Semaq Beri adult males to allocate the greater part of time spent in blowpipe hunting and fishing to the alternatives with higher return rates. Emphasis was laid on stability of catch when there was no other difference in return rate. The people, however, sometimes behaved contrary to these principles; decision-making processes of food procurement clearly include factors that are difficult or impossible to assess in quantitative terms.

## Hunting Focus

One of the most conspicuous features of Semaq Beri blowpipe hunting is a high concentration on only a few species, and this is examined from three perspectives: (1) ecology (behavioral characteristics and population densities) of prey species, (2) the hunters' decisions for maximizing return rate, and (3) technological efficiency of the blowpipe and darts.

### *Ecology of Prey Species*

While the frequencies of kill roughly correlated with the numbers of encounters among the species pursued, it is rather doubtful that the difference in frequency of encounter is a simple reflection of relative abundance or population densities of the species concerned in the present study area. According to Harrison (1969, pp. 174-178), trapping in primary forest in Selangor indicated diurnal squirrel population of 0.7 individual/ha, and the overall population density of flying squirrels is estimated as the same as that of diurnal squirrels (Medway, 1978, p. xvii). On the other hand, observations at a game reserve in Pahan indicated that six species of higher primates (dusky and banded leaf monkeys, long-tailed and pig-tailed macaques, white-handed gibbon, and siamang) together amounted to 0.5 individual/ha (Medway & Wells, 1971), while other observations gave a higher figure (1.4 individuals/ha) to the six species (Curtin and Chivers, 1978, p. 458).

Anyway, the difference in population density between higher primates and diurnal squirrels in the published data is not larger than the difference in frequency of encounter observed in the study area. Larger forest-dwelling ungulates and carnivores are in general much less common because they require wider areas to support each individual in comparison with smaller mammals. Therefore, the fact that the animals were rarely encountered during the hunts was due to their sparse population in the study area.

The searching pattern of blowpipe hunting is likely to have amplified the bias in frequency of encounter for some species of animals. The hunters depend mainly on hearing to locate potential game while walking in the forest in the daytime. Therefore, it is very difficult to find animals which are active only by night or at dusk, such as flying squirrels, flying fox, civets, musangs, and other larger ungulates. Gregarious species are likely to be located more easily than solitary species because they are apt to make more noise. The hunters' searching was not localized in specific spots or patches, such as waterholes and groves of fruit trees where various animals gather, but generalized; they "ramble" about a wide area. In this respect, it is the gregarious mammals ranging widely during the day, that is, higher primates, which man encounters with the highest frequency during a forest walk. On the other hand, it was quite probable that the hunters encountered the same group of monkeys several times in the day's hunt, as the course of hunt intersected frequently the traveling route of the group of monkeys. These elements must have magnified the presence of the higher primates over their actual abundance compared to other mammal species.

Aside from a lot of obstacles, such as shrubs and leaves, between a blowpipe and a target, there is a technological problem in aiming at a ground-dwelling animal. A shot becomes less accurate as a target comes closer to horizontal. An experiment done with Amazonian hunters indicated that the average distance at which the hunters could hit a monkey-sized target decreased by about 40% (from 25–40 m) as the target moved from vertical angle to horizontal (Yost and Kelly, 1983, pp. 199-200).

The next problem concerning the bias in the catches is a high concentration on the dusky leaf monkey among the five species of primate, which accounted for 87% of the total catches of primates in weight. The frequency of encounter with the dusky leaf monkey during the study period was higher than with the other four species, accounting for 64% of the total number of encounters with the higher primates. Although the populations of the two species of macaques and the white-handed gibbon were apparently far less than the leaf monkeys in the study area, the large difference in frequency of encounter between the two sympatric leaf monkey species cannot be explained only by the difference in abundance. The published data, conversely, indicate that the banded leaf monkey is more abundant than the dusky leaf monkey in any type of forest of Malaysia (McClure, 1964; Southwick and Cadigan, 1972; Chivers, 1973; Curtin and Chivers, 1978; Mackinnon and Mackinnon, 1980), although we cannot deny a specific population pattern in the study area.

There is a possibility that the difference in social organization and home range size might have produced the difference in frequency of encounter. As mentioned previously, the dusky leaf monkey shows large group structure made up of small cohesive subgroups consisting of two to four. The large group of monkeys will travel together in the early morning but will split into subgroups for feeding and resting during the day (Curtin and Chivers, 1978, p. 455). On the other hand, the banded leaf monkey shows stronger group cohesion; the large group stays together without forming subgroups for feeding, resting, and traveling (Curtin, 1980, p. 117). As compared with the banded leaf monkey, the dusky leaf monkey has shorter day range and smaller territory (Curtin and Chivers, 1978, pp. 457-458). It is very likely that dusky leaf monkeys which split into subgroups and disperse widely in the forest are encountered more easily than banded leaf monkeys which range in a large group over a wider area (Fig. 5). Furthermore, the hunters can predict more easily the daily foraging route of dusky leaf monkeys because of the conservative nature of their ranging pattern and territory use (Curtin and Chivers, 1978, pp. 455).

### *Application of Optimal Diet Breadth Model to Prey Selection*

The problem of prey selection in blowpipe hunting with the aid of optimal diet breadth model is one of the major analytical categories in optimal foraging theory (Smith, 1983, p. 626). The procedure for construction of the model basically follows that of Hill and Hawkes (1983, pp. 165-170) for the Ache of eastern Paraguay.

For foragers, diet breadth is defined as a set of food (prey) types that will be pursued if encountered during a search, and the optimal diet breadth is the food set that will maximize the energetic return per unit of foraging time. The underlying assumption in the model is that foragers will continue to procure food types that give them greater energetic returns against cost

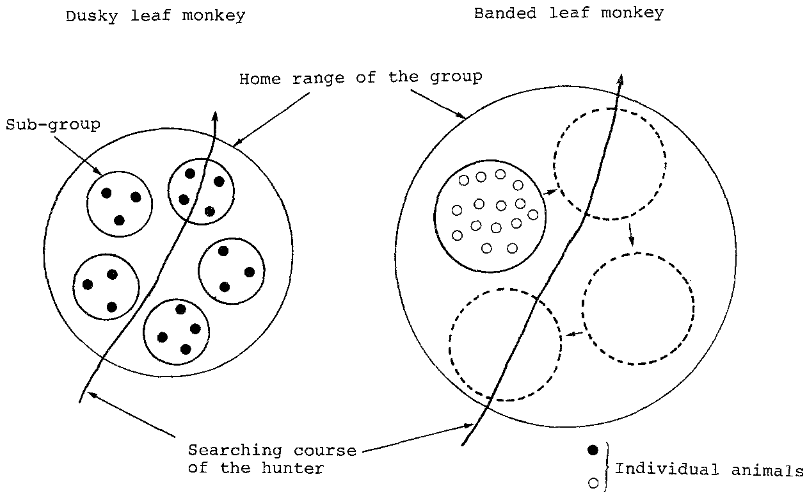



**Fig. 5.** Model for the relationship between easiness of locating leaf monkeys and their social organization. Dusky leaf monkeys disperse in subgroups in feeding and resting, while banded leaf monkeys move as a whole group. The two sympatric species are frequently found at the same place.

in terms of time spent in procuring them, and they will stop procuring food types that decrease their returns against cost.

To construct the optimal diet breadth model (MacArthur and Pianka, 1966; Pyke, Pulliam, and Charnov, 1977; Charnov, 1976), food types or resources must be ranked according to the ratios of energetic returns to the costs of acquiring and processing the resources once they are encountered. Here, the cost is defined as "handling" time. Total foraging time is partitioned into two mutually exclusive categories in the model: "search" time which is generalized over all food types, and "handling" time which is spent in acquiring and processing them. When a forager encounters a potential food item, he must decide whether to take it or pass it by. The model shows that energetic returns will be maximized if foragers take only those food types for which the ratio of return is equal to or higher than the average return rate they get for foraging in general and they should ignore all potential food types for which the ratio is lower than the average return rate (Hawkes, Hill, and O'Connell, 1982, p. 388). Stated algebraically, an optimal forager will maximize $E/T$, and a food type $i$ will be included in the diet only if $E/T \leq Ei/hi$ where $E$ = total energy (kcal) acquired in foraging, $T$ = total foraging time including total handling time and total searching time ($= Ts + hi$), $Ei$ = energy (kcal) available in a unit of food type $i$, $Ts$ = total search time, and $hi$ = handling (acquiring and processing) time per unit of food type $i$. Any food type will be added to the diet in order of its rank only as long as its return per unit handling time exceeds the average return rate for searching for, acquiring, and processing all food types of higher rank. Food types that fail to meet this criterion will be excluded from the diet. Whether or not a potential resource is in the optimal diet is independent of its abundance (encounter rate), and depends only on the abundance of higher-ranking food types. A potential resource is out of the optimal diet no matter how abundant it becomes. High-ranked food types may be so rarely encountered that they contribute only a very small proportion of the diet. Thus, the ranking of the food types in the model has nothing to do with the quantitative importance of a food type to optimal foragers, but predicts which food types are likely to enter or leave the diet, and in what order (Hill and Hawkes, 1983, p. 166). If the encounter rates for higher-ranked food types (the abundance) fall, average returns from searching for, procuring, and processing them will also decrease, and lower-ranked food types will be added to the diet as their rank values (*Ei/hi*) exceed the average return rate (*E/T*), and *vice versa* (O'Connell and Hawkes, 1984, p. 510).

Tables VIII and IX show the costs of handling and the energetic returns to handling time for each prey item captured in blowpipe hunting on the basis of the quantitative data obtained in the 58 hunts participated in. The rank of each item is given according to returns upon encounter (*Ei/hi*). Handling time (*hi*) for a specific item is the sum of the pursuit time for that item upon encounter, including unsuccessful pursuits, and the butchering time of the item. No successful pursuit was observed for middle-sized squirrels such as Prevost's squirrel (*Callosciurus prevostii*). If the success rate for the middle-sized squirrels is assumed to be equal to that for the giant squirrels, and the average time it takes to kill the former is estimated to be one third as many minutes as that for the latter in proportion to the body sizes, the energetic return per hour of handling time (*Ei/hi*) is calculated at 480 kcal/hr.

Figure 6 shows the ratios of energetic return to handling time (*Ei/hi*) for each of the prey items ordered by rank (the triangular points descending from left to right) and the average returns for hunting in general (*E/T*) that result from the addition of each of these prey items. The latter numbers are derived as follows. The total search time (*T*) is estimated at 1052.1 hours on the basis of the average activity budget of the blowpipe hunts participated in. If only the top-ranked item (the dusky leaf monkey) was taken, average return ratio would be 435 kcal/hr, which is obtained by dividing the energetic return for the item ($6.6 \times 10^5$ kcal) by the total search time plus handling time for it (1052.1 + 408.6 hr). Adding the second-ranked prey item (the banded leaf monkey) changes the average return ratio, as the energetic return for the second-ranked prey item is added to the numerator, and the handling time for it is added to the denominator. The average return ratio (*E/T*) will rise to 511 kcal/hr. Thus, in order to calculate the average

**Table VII.** Daily Returns of Blowpipe Hunting and Fishing

| | Edible weight (kg)[a,b] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | No return | 0.0-5.0 | 5.0-10.0 | 10.0-15.0 | 15.0-20.0 | 20.0-25.0 | 25.0-30.0 | 30.0-35.0 | 35.0-40.0 | 40.0-45.0 | Total |
| Blowpipe hunting | | | | | | | | | | | |
| Village area | | | | | | | | | | | |
| Numbers of hunts | 108 (57.4) | 37 (19.7) | 30 (16.0) | 10 (5.3) | 2 (1.1) | 1 (0.5) | — | — | — | — | 188 (100.0) |
| Camping area | | | | | | | | | | | |
| Number of hunts | 62 (67.4) | 7 (7.6) | 15 (16.3) | 8 (8.7) | — | — | — | — | — | — | 92 (100.0) |
| Fishing | | | | | | | | | | | |
| Village area | | | | | | | | | | | |
| Number of instances | 37 (47.4) | 27 (34.6) | 7 (9.0) | 4 (5.1) | 1 (1.3) | — | — | 1 (1.3) | — | 1 (1.3) | 78 (100.0) |
| Camping area | | | | | | | | | | | |
| Number of instances | 14 (13.8) | 71 (70.3) | 10 (9.9) | 2 (2.0) | 2 (3.0) | 1 (1.0) | — | — | — | — | 101 (100.0) |

[a]Daily returns per hunt or per fishing instance.
[b]Percentages are given in parentheses.

**Table VIII.** Time Required for Handling Prey Items

| Prey item | Number of stalks observed | Time required for handling (hr)[a] | | | | Total handling time (hr) | Catch (kg) | Cost of handling (hr/kg) |
|---|---|---|---|---|---|---|---|---|
| | | Stalking/shooting | Waiting | Retrieving | Butchering | | | |
| Dusky leaf monkey | 91 | 41.0 | 19.6 | 2.5 | 12.8 | 75.9 | 160.0 | 0.47 |
| Banded leaf monkey | 33 | 19.2 | 8.7 | 1.3 | 5.7 | 34.9 | 71.3 | 0.49 |
| White-handed gibbon | 5 | 1.4 | 0.9 | 0.1 | 0.5 | 2.9 | 5.7 | 0.51 |
| Musangs or civets | 4 | 1.8 | 1.9 | 0.1 | 0.6 | 4.4 | 7.4 | 0.59 |
| Giant squirrels | 6 | 0.6 | 1.1 | 0.1 | 0.5 | 2.3 | 3.2 | 0.72 |
| Long-tailed and pig-tailed macaques[b] | 10 | 5.9 | 1.6 | (0.1) | (0.7) | (8.3) | (8.5) | (0.98) |
| Middle-sized squirrels[c] | 8 | 0.4 | (0.2) | (0.1) | (0.1) | (0.8) | (0.5) | (1.59) |
| Small-sized squirrels | 4[d] | | 0.23 (Waiting + Retrieving) | | | 0.23 | 0.10 | 2.32 |
| Small-sized birds | 2[d] | | 0.10 (Waiting + Retrieving) | | | 0.10 | 0.05 | 2.00 |

[a]Estimated time in parentheses.
[b]One long-tailed macaque was killed, but the hunter could not retrieve it because the carcass got caught in the high branches of the tree.
[c]Middle-sized squirrels such as *Callosciurus* spp. were never observed to be killed. The figures in parentheses were estimated (see text).
[d]Included are the squirrels or birds which appeared in the campsites and were shot for fun.

**Table IX.** Energetic Returns to Handling Time and Ranking of Prey Items[a]

| Prey item | Total catches (kg) | Kcal/kg | Cost of handling (hr/kg) | Total handling time (hr) | *Ei/hi* | Rank | *E/t* |
|---|---|---|---|---|---|---|---|
| Dusky leaf monkey | 869.3 | 760 | 0.47 | 408.6 | 1620 | 1 | 452 |
| Banded leaf monkey | 168.3 | 760 | 0.49 | 82.5 | 1550 | 2 | 511 |
| White-handed gibbon | 43.4 | 760 | 0.51 | 22.1 | 1490 | 3 | 525 |
| Musangs or civets | 17.8 | 760 | 0.59 | 10.5 | 1290 | 4 | 530 |
| Giant squirrels | 4.5 | 760 | 0.72 | 3.2 | 1060 | 5 | 531 |
| Long-tailed macaque<br>Pig-tailed macaque | 38.5 | 760 | 0.98 | 37.2 | 780 | 6 | 537 |
| Middle-sized squirrels[b] | – | 760 | 1.59 | – | 480 | 7 | – |
| Small-sized squirrels | (0.1) | 760 | 2.32 | (0.23) | 330 | 8 | – |
| Small-sized birds | (0.05) | 460 | 2.00 | (0.10) | 230 | 9 | – |

[a]Total search time = 1052.1 hr.
[b]The figures were estimated.

return ratios gained after the addition of lower-ranked items, their energetic contributions are simply added to the numerator and their handling time to the denominator.

The optimal diet breadth model predicts that the lower-ranked items, such as middle-sized and small-sized squirrels, and small birds, would reduce the overall rate of returns, and that, therefore, these prey items will not be taken upon encounter. The model can give a reasonable explanation as to why the blowpipe hunters exclude the terrestrial animals on which the poison applied to the darts is effective. The terrestrial mammals such as barking deer and mouse-deer are quite hard to track and to find after the darts hit them. Likewise, the large birds such as hornbills can fly away before the poison takes effect. Therefore, much time will be required for tracking and retrieving the animal hit. These terrestrial mammals and large birds are ranked the lowest because the return per handling hour (*Ei/hi*) for them is extremely low. The addition of these species to the diet will apparently lower the average return rate.

According to the optimal diet breadth model, the highly-focused prey selection in Semaq Beri blowpipe hunting may be regarded as adaptive behavior maximizing the return rate of hunting.

## *Comparison of Technological Efficiency of Blowpipe Hunting*

There are various technological differences between the blowpipe hunting of the Waorani in Ecuador (Yost and Kelly, 1983) and that of the Semaq

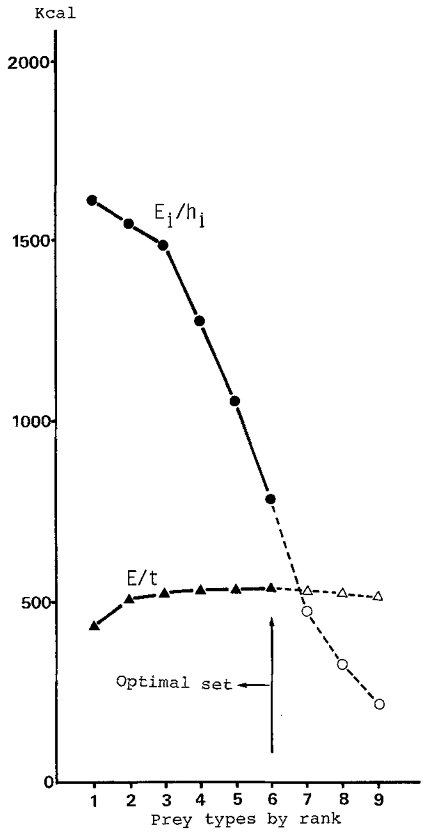



**Fig. 6.** Optimal diet breadth model.

Beri. The most remarkable ones are in success rate, return rate, and range of animal species pursued (Table X). The Waorani hunters have a success rate approximately 2.4 times higher, and return rate 4 times higher than the Semaq Beri. While the Semaq Beri focused entirely on tree-dwelling animals, about 15% of the total catches of the Waorani derived from ground-dwelling animals, including various species of mammals and Geornithes birds such as curassows and tinamous. Aves, almost completely neglected by the Semaq Beri, accounted for nearly 45% of the total catches of the Waorani. The Waorani do not hesitate to shoot small-sized animals of less than 2 kg, which constituted nearly 60% of the total number of animals killed, while they also shot down large-size animals such as peccaries and deer. On the other hand, 98% of the animals killed by the Semaq Beri were between 2–10 kg.

Although these differences must be mainly derived from the difference in composition and density of fauna in their habitats, to some extent they

**Table X.** Comparison of Blowpipe and Darts between the Waorani and the Semaq Beri

| Item | Waorani[a] | Semaq Beri |
|---|---|---|
| Blowpipe | | |
| Length (average) | 2.75 m | 1.89 m |
| Diameter of bore (average) | 12 mm | 10 mm |
| Volume (average) | 311 cc | 148 cc |
| Weight | 2.5–3.2 kg | 200–320 g |
| Dart | | |
| Length (average) | 39 cm | 23 cm |
| Diameter of shaft | 2–3 mm | 2.4 mm average |
| Weight (average) | 2.5 g | 0.7 g |
| Average time required for making darts and applying poison | 4.7 min/dart | 10.2 min/dart |
| Killing power | | |
| No poison | Animals of 80 g or so | Small birds of less than 50g |
| With poison | 15–20 min required for a wooly monkey weighing 6.9 kg average | 38 min average for a leaf monkey weighing 6.3 kg average, ranging 6–80 min |
| Number of darts carried per hunt | Over 100 (300 in maximum) | 25.8 average, ranging 10–48 |
| Efficiency | | |
| Return rate | 1.62 kg/hr in whole weight | 0.43 kg/hr in whole weight |
| Success rate[b] | 94.3% ($n$ = 433) | 39.3% ($n$ = 280) |

[a]Yost and Kelly (1983).
[b]The percentage of successful hunts to the total number of hunts.

are assumed to be related directly to the difference in killing power of darts. The Waorani blowpipe gives more velocity to a dart than that of the Semaq Beri because it is much longer. The longer the blowpipe, the more velocity the hunter can put behind the dart and the more easily he aims it, although longer blowpipes require more precise control and stronger lungs for an effective shot (Yost and Kelly, 1983, p. 196). The longer and heavier dart of the Waorani has higher penetration potential than that of the Semaq Beri if enough velocity is put behind it. While the critical killing power is in the poison for the darts of both the Waorani and the Semaq Beri, the Waorani dart itself, that is, a dart without poison, has a stronger killing power. Judging from the time required for killing animals, the Waorani poison is assumed to have higher potency than that of the Semaq Beri.

The Waorani are willing to shoot the ground-dwelling animals and such larger birds as toucans sitting on the top of the tree probably because of the stronger killing power of the darts, whereas the Semaq Beri usually passed by these animals because the relatively weak killing power of their darts may give them enough time to run or fly away before the poison takes effect.

The Waorani usually carry many more darts for a hunt than the Semaq Beri (100–300 vs. 10–50, respectively). This is probably due to the difference in cost for making darts and applying the poison. A dart of the Waorani requires 4.7 min in average while that of the Semaq Beri requires 10.2 min. The Waorani are willing to risk shots at small birds of less than 50 g. The Semaq Beri, on the other hand, may pass by them to save the darts until they encounter larger animals such as monkeys or gibbons. Thus, the differential costs in preparing darts may further explain the difference in range of animal species pursued by the two groups.

## ACKNOWLEDGMENTS

I wish to express my heartfelt thanks to the Semaq Beri and Mr. Tara B. Diok, the field assistant of the JOA, for generously accepting me. I wish also to thank Dr. Anthony Walker of Ohio State University for his extensive help and cooperation. I am greatly indebted to Dr. Baharon Azhr Raffie'i, Director General of the JOA, and other staff of the Department, for granting me permission to conduct research. My thanks also to Professors Hitoshi Watanabe of Waseda University, Shuichi Nagata of Toronto University, Kazuro Hanihara of the International Center for Japanese Cultural Studies, Toshisada Nishida of Kyoto University, Tadashi Tanno of Hirosaki University, Drs. Ryutaro Ohtsuka of University of Tokyo, and Shun Sato of Tsukuba University. The field research was financially supported by the Little World Foundation. I am grateful to the late Professor Kazuo Terada and Professor Yoshio Ohnuki of the University of Tokyo for arranging the support.

## REFERENCES

Charnov, E. L. (1976). Optimal foraging: Attack strategy of a mantid. *American Naturalist* 109: 267-272.

Chivers, D. J. (1973). An introduction to the socio-ecology of primates. In Michael, P. P., and Crook, J. H. (eds.), *Comparative Ecology and Behavior of Primates.* Academic Press, London.

Curtin, S. H. (1980). Dusky and banded leaf monkeys. In Chivers, J. D. (ed.), *Malayan Forest Primates: Ten Years' Study in Tropical Rain Forest.* Plenum Press, New York.

Curtin, S. H., and Chivers, D. J. (1978). Leaf eating primates of Peninsular Malaysia: The siamang and the dusky leaf monkey. In Montgomery, G. G. (ed.), *The Ecology of Arboreal Folivores.* Smithonian Institute Press, Washington, D.C.

Endicott, K. (1969). Negrito blowpipe construction on the Lebir River, Kelantan. *Federation Museums Journal* 14: 55-69.

Hames, R. B. (1979). A comparison of the efficiencies of the shotgun and the bow in neotropical forest hunting. *Human Ecology* 7: 219-252.

Harrison, J. L. (1969). The abundance and population density of mammals in Malayan lowland forests. *Malayan Nature Journal* 23: 174-178.

Hawkes, K., Hill, K., and O'Connell, J. (1982). Why hunters gather: Optimal foraging and the Ache of eastern Paraguay. *American Ethnologist* 9: 379-391.

Hayden, B. (1981). Subsistence and ecological adaptation of modern hunter-gatherers. In Harding, R. S. O., and Teleki, G. (eds.), *Omnivorous Primates.* Columbia University Press, New York.

Hill, K. (1982). Hunting and human evolution. *Journal of Human Evolution* 11: 521-544.

Hill, K., and Hawkes, K. (1983). Neotropical hunting among the Ache of eastern Paraguay. In Hames, R. B., and Vickers, W. T. (eds.), *Adaptive Responses of Native Amazonians.* Academic Press, New York.

Ichikawa, M. (1983). An examination of the hunting-dependent life of the Mbuti net hunters, eastern Zaire. *African Study Monographs* 1: 55-68.

Jochim, M. A. (1981). *Strategies and Survival: Cultural Behavior in an Ecological Context.* Academic Press, New York.

Kuchikura, Y. (1987). *Subsistence Ecology among Semaq Beri Hunter-Gatherers of Peninsular Malaysia.* Hokkaido Behavioral Science Report, Series E, No. 1. Department of Behavioral Science, Hokkaido University.

MacArthur, R. H., and Pianka, E. R. (1966). On optimal use of a patchy environment. *American Naturalist* 100: 603-609.

MacKinnon, J. R., and MacKinnon, K. S. (1980). Niche differentiation in a primate community. In Chivers, D. J. (ed.), *Malayan Forest Primates: Ten Years' Study in Tropical Rain Forest.* Plenum Press, New York.

Marks, S. A. (1977). Hunting behavior and strategies of Valley Bisa in Zambia. *Human Ecology* 5: 1-36.

McClure, H. A. (1964). Primates in the depterocarp forest of the Gomback Valley. *Primates* 5: 39-58.

Medway, L. (1978). *The Wild Mammals of Malaya (Peninsular Malaysia) and Singapore* (2nd Ed.). Oxford University Press, Kuala Lumpur.

Medway, L., and Wells, D. R. (1971). Diversity and density of birds and mammals at Kuala Lompat, Pahang. *Malayan Nature Journal* 24: 238-247.

O'Connell, J. F., and Hawkes, K. (1984). Food choice and foraging sites among the Alyawara. *Journal of Anthropological Research* 40: 501-535.

Pyke, G. H., Pulliam, H. R., and Charnov, E. L. (1977). Optimal foraging: A selective review of theory and tests. *Quarterly Review of Biology* 52: 137-154.

Rambo, A. T. (1978). Bows, blowpipes, and blunderbusses: Ecological implication of weapons change among the Malaysian Negritos. *Malayan Nature Journal* 32: 209-216.

Saffirio, G., and Scaglion, R. (1982). Hunting efficiency in acculturated and unacculturated Yanomama villages. *Journal of Anthropological Research* 38: 315-327.

Schebesta, P. (1954). *Die Negrito Asien* (Vol. II). St. Gabriel-Verlag, Modling.

Smith, E. A. (1983). Anthropological application of optimal foraging theories. *Current Anthropology* 24: 625-651.

Southwick, C. H., and Cadigan, F. C., Jr. (1972). Population studies of Malaysian primates. *Primates* 13: 1-18.

Williams-Hunt, P. D. R. (1952). *An Introduction to Malayan Aborigines.* Government Press, Kuala Lumpur.

Yost, J. A., and Kelly, P. M. (1983). Shotguns, blowguns, and spears: The analysis of technological efficiency. In Hames, R. B., and Vickers, W. T. (eds.), *Adaptive Responses of Native Amazonians.* Academic Press, New York.