The *Journal of Ethnobiology* is published semi-annually by the Society of Ethnobiology (www.ethnobiology.org). Manuscripts for publication and book reviews should be sent to the appropriate editors as listed in the inside back cover of this issue.

ISSN 0278-0771

COVER ILLUSTRATION: Wayzaro Halufti Tesfaye pounding grain (D'Andrea and Mitiku, this issue Figure 5).

Journal of Ethnobiology

VOLUME 22, NUMBER 2 WINTER 2002

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ETHNOBIOTICA

One of my favorite quasi-ethnobotanical quotes is: "Like the cabbage it so much resembles, the *Homo sapiens* brain, having arisen within the framework of human culture, would not be viable outside it" (Geertz 1973:68). Our perception of and interaction with the physical world is inextricably tied to our biological and cultural natures, and this idea is central to ethnobiology.

The culture-dependent intelligence of people creates problems unique to our species. Most animals do not have to worry or even think about how their mere existence changes their environment. Their populations may remain stable over time or may rise and crash cyclically (and of course, extinction is always an option). People (as a species), on the other hand, have chosen a path that has wrought substantial changes on the planet. If ethnographic analogy provides any indication for the past, ancient foragers knew how to promote the propagation of desirable resources, but their impact on the landscape would not have been that great. Regardless of theory, the archaeological record shows that the foraging lifestyle was indeed sustained for tens of thousands of years. Some of those foragers, however, became sedentary and started farming. Agriculture allowed populations to concentrate, and also to expand. Yes, those early farmers may have pushed foragers to marginal environments, but from their point of view, the successes of the agricultural way of life outweighed the failures. Pre-industrial agriculture lasted thousands of years, because the earth is vast and people's ability to change it just wasn't that great. No way of life is sustainable forever unchanged, but one big difference with times past is the accelerated pace of change in the modern world. And unlike our forbears, we make decisions about resource use and allocation today that may well affect us tomorrow.

The articles in this issue of the *Journal of Ethnobiology* at least tangentially touch on the questions of sustainable resource use in a changing world. D'Andrea and Mitiku discuss the continuing use of one of the world's first domesticated crops, emmer wheat; Gertsch et al. (palms) and Silvano and Begossi (fish) give examples of the intersection of folk knowledge and resource management; and Bandeira et al. and Lyon and Hardesty give two case studies that directly deal with aspects of sustainable agroforest and forest ecosystems.

Take the opportunity to discuss the many ramifications of these and other topics at the 26th Annual Meeting of the Society of Ethnobiology, which will be held at the University of Washington, Seattle, March 26–29, 2003. The general theme is "Ethnobiology and Sustainability." Dr. Fikret Berkes, author of *Sacred Ecology,* professor of Natural Resources at the University of Manitoba, will be our keynote speaker. The deadline for abstracts is February 14, 2003, but check the Society's website for the most current information and details: **ethnobiology.org.** You may also contact Eugene Hunn, the meeting's organizer, at the Department of Anthropology, Box 353100, University of Washington, Seattle, WA 98195–3100. Telephone: (206) 543-6825. E-mail: hunn@u.washington.edu.

I hope to see you in Seattle!

Naomi

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Journal of Ethnobiology 22(2): 179–217 Winter 2002

TRADITIONAL EMMER PROCESSING IN HIGHLAND ETHIOPIA

A. CATHERINE D'ANDREA[a] and MITIKU HAILE[b]
[a] *Department of Archaeology, Simon Fraser University, Burnaby, British Columbia, Canada, V5A 1S6*
[b] *Mekelle University, P.O. Box 231, Mekelle, Ethiopia*

ABSTRACT.—The cultivation of emmer wheat has all but disappeared in the modern world. The northern highlands of Ethiopia represent one of the few remaining regions where this cereal continues to be grown for human consumption. We present the results of an ethnoarchaeological study of non-mechanized emmer processing technology documented in south-central Tigrai, Ethiopia, focussing on small-scale household production. Despite high processing costs, land and water shortages, and the availability of more productive wheat species, the cultivation of emmer has persisted in highland Ethiopia. The results of this study draw attention to the role of women and shared labor in the household processing of hulled wheats and intercropped cereals. Processing techniques observed in Tigrai are compared to experimental studies, ethnoarchaeological, and historical sources on emmer processing, and implications for interpretations of the archaeological record are discussed.

Key words: Tigrai, ethnoarchaeology, intercropping, *Triticum dicoccum*, emmer processing, women in agricultural production.

RESUMEN.—El cultivo de escanda o trigo *emmer (Triticum dicoccum)* ha desaparecido prácticamente en el mundo moderno. Las tierras altas del norte de Etiopía son una de las pocas regiones que quedan donde este cereal aún se cultiva para el consumo humano. Se presentan los resultados de un estudio etnoarqueológico sobre la tecnología de procesado no mecanizado de la escanda documentada en el centro-sur de Tigrai, en Etiopía, centrado en la producción doméstica a pequeña escala. A pesar de los altos costes de procesado, la escasez de terreno y agua, y la posibilidad de acceso a variedades de trigo más productivas, el cultivo de escanda ha subsistido en las tierras altas de Etiopía. Los resultados de este estudio llaman la atención sobre el papel de las mujeres y el trabajo compartido en el procesado doméstico de los trigos con cáscara y los cultivos mixtos de cereales. Las técnicas de procesado observadas en Tigrai se comparan con estudios experimentales y fuentes etnoarqueológicas e históricas sobre el procesado de la escanda, y se discuten algunas implicaciones para la interpretación de los restos arqueológicos.

RÉSUMÉ.—La culture du blé amidonnier a pratiquement disparu du monde moderne. Les hauts plateaux du nord de l' Éthiopie représentent une des dernières régions où cette céréale est encore cultivée à des fins de consommation humaine. Dans cet article, les auteurs présentent les résultats d'une étude ethnoarchéologique menée dans le centre-sud de la région de Tigré, en Éthiopie. Cette étude documente les techniques de traitement non-mécanisé du blé amidonnier, et porte principalement sur l'unité de production à petite échelle des ménages. Malgré les coûts de transformation élevés, le manque de terres et d'eau, et la disponibilité d'espèces de blé à meilleurs rendements, la culture du blé amidonnier continue dans les hauts plateaux éthiopiens. Les résultats présentés dans cet article attirent l'attention sur le rôle des femmes et le partage des tâches dans le traitement des blés décortiqués et des céréales intercalaires à l'échelle des ménages. Les observations effectuées dans la région de Tigré sont comparées à des études expérimentales, ethnoarchéologiques et à des sources historiques documentant les techniques de transformation du blé amidonnier. Finalement, les auteurs examinent les implications d'une telle étude pour l'interprétation des données archéologiques.

INTRODUCTION

Emmer wheat (*Triticum turgidum* ssp. *dicoccum* (Schrank) Thell.) was a cereal integral to life in the ancient world. From its early beginnings during the mid-eighth millennium B.C., emmer quickly grew to dominate wheat production in the Near East, subsequently spreading to Europe, the Transcaucasus and eventually to the Indian subcontinent. Hulled wheats[1] such as emmer were eclipsed by free-threshing forms during the Near Eastern Bronze Age, early in the fourth millennium B.C. (Zohary and Hopf 2000:46–51), and never regained their early prominence. A minor crop grown today in isolated regions more commonly for animal than human consumption (Gunda 1983; Nesbitt and Samuel 1996:41–47), emmer is now mainly of interest to scientists concerned with conservation of agrobiodiversity (Negassa 1986; Nesbitt et al. 1996:234). Not surprisingly, it is of considerable significance to archaeobotanists conducting studies of ancient subsistence, and has been the focus of several investigations relating to processing technology, especially the dehusking of emmer spikelets[2] (Hillman 1984a, 1984b; Nesbitt and Samuel 1996; Samuel 1993, 2000). The first systematic field studies of hulled wheat processing were conducted by Hillman (1973, 1981, 1984a, 1984b), while detailed experimental replications have since been completed (e.g., Meurers-Balke and Lüning 1992, 1999; Samuel 1993). A comprehensive review of experimental and archaeobotanical research on hulled wheats is provided by Nesbitt and Samuel (1996:45–54), who emphasize the need for further ethnoarchaeological investigation to focus on dehusking and the role of parching. Although experimental replications and examination of ancient texts and reliefs have produced useful insights into these practices (e.g., Bower 1992; Meurers-Balke and Lüning 1999; Murray 2000; Samuel 1993, 2000), ethnoarchaeological studies of emmer production embedded in a living tradition have the potential to reveal more in the way of technological and social issues relating to the processing of this cereal.

The link between food processing/cooking and women's labor has been demonstrated in cross-cultural ethnographic studies (Kurz 1987; Murdock and Provost 1973). In particular the association between women and the processing of plant products is rather striking (Crown 2000:222–225; Kurz 1987:45; Watson and Kennedy 1991:255–259). Although both men and women share the burden of crop production and processing overall, in non-mechanized societies the latter stages (fine sieving, hand-sorting, pounding, and grinding) tend to fall predominantly in the domain of women. Interestingly, many of the products and by-products of

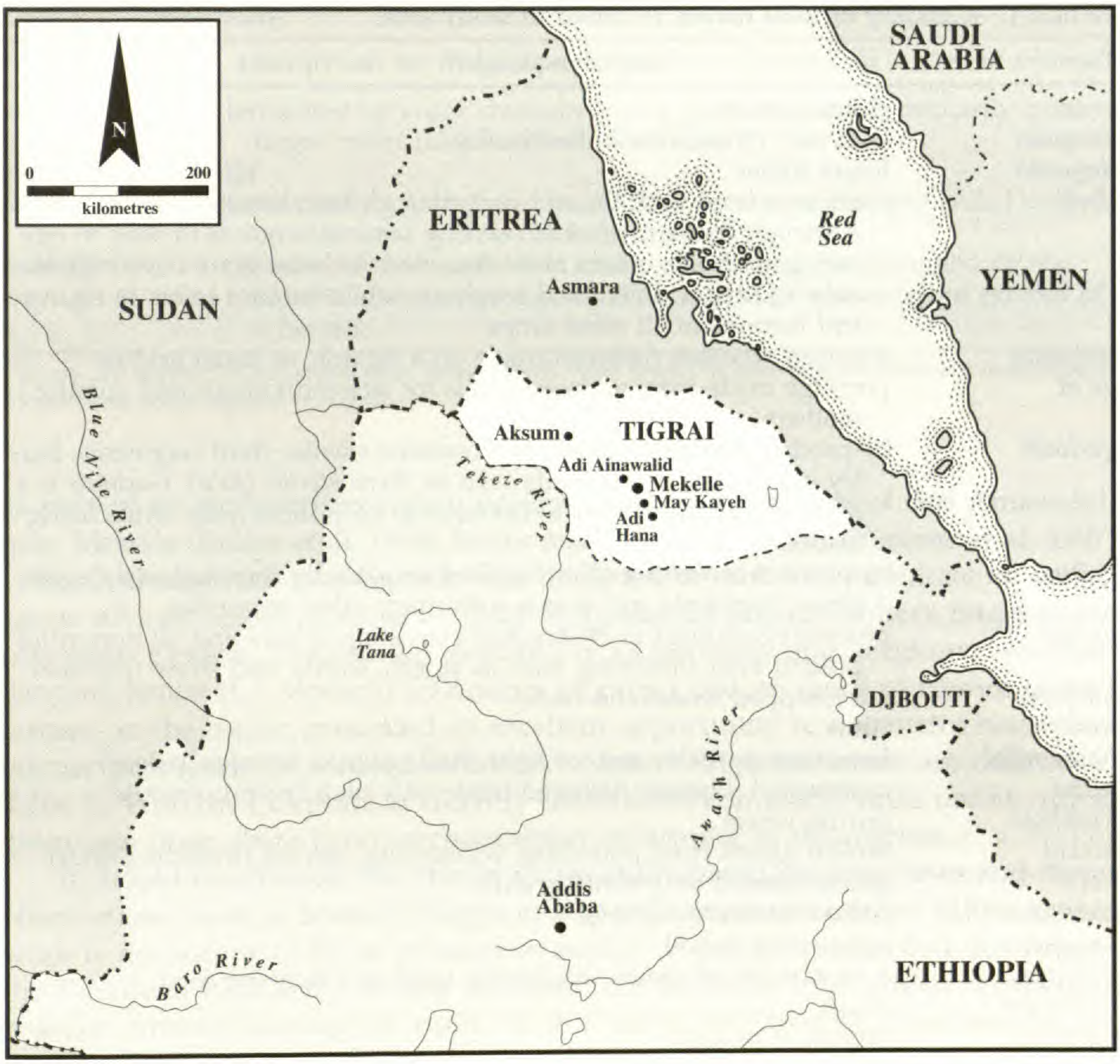


FIGURE 1.—The study area.

cereal processing identified from archaeological sites originate from these latter stages, including accidents of parching prior to pounding, winnowing and sieving before and after pounding, and storage of prime grain (Hillman 1984a:12). Although it is ill-advised to assume that gender roles in crop production are static in time and space, given the pattern evident in the ethnographic record, the possibility of using these kinds of remains as material correlates of men's and women's activities warrants serious investigation. Studies of gender based on paleoethnobotanical data are rare, but those that are available have produced valuable insights (e.g., Hastorf 1991; Watson and Kennedy 1991). Ethnoarchaeology has much to contribute to such research, and although the gendered division of labor in crop processing has been alluded to in some studies (e.g., Reddy 1991: 23), the relative contribution of males and females to these tasks has not been considered in detail.

Our study documents traditional emmer processing in and around the villages of Adi Hana and Mai Kayeh in south-central Tigrai, northeastern Ethiopia (Figure 1). Fieldwork was carried out in the autumn of 1997 and spring of 1998,

TABLE 1.—Glossary of local names recorded in study area.

Tigrinya terms*	English equivalent (or description)
arras	emmer wheat
burguda	land race of two-row hulled barley
dagusha	finger millet
ebuk	chaff associated with the ear, including glumes, lemmas, and paleas. Although the term ***ebuk*** is used by some informants to refer to emmer grain hulls, others insist that ***ebuk*** includes grain coverings of only tef, finger millet, and sorghum, while ***burkatz*** refers to equivalent features in all other crops
embasha	leavened wheaten flatbread made on a ceramic or metal griddle
ga'at	porridge made from various cereals for sick individuals and nursing mothers
guchach	by-product similar to ***gurdie*** but contains smaller chaff fragments, barley grains, and weed seeds such as *Avena sterilis* (***fa'a***). ***Guchach*** is a high quality fodder fed to donkeys to keep them quiet while being loaded
gulam	by-product consisting of unthreshed or partially threshed ears, large straw fragments and stones with many other impurities
gurdie	processing product or by-product consisting of ears and all impurities present after threshing, such as stones, weeds, and straw fragments
hanfetse	intercropped wheat and barley
haser	straw
haser nifai	fine straw particles and/or light chaff (glumes, lemmas, paleas)
kicha	unleavened wheaten flatbread made only on a ceramic griddle
kinkinai	durum wheat
kitkat	broken grains from pounding, winnowing, sieving (including flour)
kollo	grains roasted on a metal griddle
kurdad	*Lolium temulentum* grains
lameda	winnowing shovel
mahoyo	a soup made of grains, commonly used as a weaning food
makoster	brush
maresha	Ethiopian plough
mechelo	rake
menelik	mass-produced metal container commonly used in measuring grain/flour, equivalent to about 650 ml
mentertar	winnowing technique using a ***sefi***
mese	winnowing fork
metahan	stone saddle quern
mihea	flat container with coarse apertures used in the field as a winnowing basket and in the household as a sieving/winnowing instrument
mihehai	sieving/winnowing technique using a ***mihea*** during household processing
mashila	sorghum
mogu	mortar
monfit	sieve
mofit tara	coarse sieve
monfit shi'i	fine sieve
mouk	thick soup made from flour
mubukats	an up-and-down motion used to toss products and by-products in household processing
saessea	two-row hulled barley land race
sefi	flat basket with no apertures, used in household winnowing
shahan	land race of bread wheat

TABLE 1.—(continued)

Tigrinya terms*	English equivalent (or description)
sua	fermented beverage consumed on a daily basis made primarily from finger millet (also sorghum and barley)
t'af	tef
taita	fermented pancake bread made from several cereals and baked only on a ceramic griddle (*injera* in Amharic)
tsumdi	measure of land equivalent to the area that can be ploughed by one team of oxen in one day, equivalent to approximately one quarter of a hectare.

* Terms are specific to the study area. Some words were found to have slightly different meanings in Aksum and other regions of Tigrai.

as part of an ethnoarchaeological project based at the village of Adi Ainawalid, near Mekelle (Butler et al. 1999; Butler and D'Andrea 2000; D'Andrea et al. 1997, 1999). Although the investigation was designed in part to concentrate on indigenous African cereals, such as tef (***t'af***;[3] *Eragrostis tef* (Zucc.) Trotter), finger millet (***dagusha***; *Eleusine coracana* ssp. *coracana* (L.) Gaertner), and sorghum (***mashila***; *Sorghum bicolor* (L.) Moench) (D'Andrea in prep.), the presence of emmer (***arras***) farmers in the region presented an excellent opportunity to document household emmer processing in a non-mechanized context (Tigrinya terms are defined in Table 1). With the exception of recently constructed communal mills used to grind grain into flour, there is no mechanization of farming in this region.

It should be stressed that this is a case study based on interviews and direct observations made at several villages in a specific geographic area.[4] Although this work is not meant to be an exhaustive survey of emmer production throughout the Ethiopian highlands, it does represent a solid basis from which to launch a broader ethnoarchaeological study of this cereal in Ethiopia. Furthermore, although an effort was made to record activities taking place prior to harvest, such as ploughing and sowing, acquiring these data was not a main priority of this research. Instead, we emphasize post-harvest activities and technology, which arguably have the greatest influence on archaeological preservation.

EMMER IN ETHIOPIA

The incredible diversity in Ethiopian wheats has been noted by many investigators (e.g., Chiovenda 1928; Ciferri and Giglioli 1939a, 1939b; Harlan 1969; Jain et al. 1975; Phillips 1995:61; Vavilov 1931, 1951). Vavilov (1951) considered Ethiopia a primary center of diversity for tetraploid[5] wheats, but it is now regarded as a secondary center (Engels and Hawkes 1991:27; Zeven and De Wet 1982:117). In Ethiopia wheat is grown under rainfed conditions over a range of elevations, but primarily between 1500 and 3000 m asl (Hailu 1991b:2; Tesfaye and Getachew 1991:48). Tetraploids occupy 60–70% of the total area of wheat under cultivation today, many of which are land races (Tesfaye 1991:289; Tesfaye and Getachew 1991:48). Of these, durum wheat predominates, and emmer is described as the most important minor wheat, although varietal diversity is not as pronounced as in durum (Hailu and Haile Mariam 1990:180).

Tetraploid wheats, including emmer, are believed to have a long history in Ethiopia, based on their evolution of diverse characteristics and numerous intermediate forms, which are most pronounced in durum (Engels and Hawkes 1991: 26–28; Hailu and Haile Mariam 1990:180; Tesfaye 1991:289–290). Some traits, such as purple grain color are endemic to Ethiopia (Getachew et al. 1995:387; Hailu and Haile Mariam 1990:182; Vavilov 1951:177; Zeven 1971). Claims have been made for the introduction of tetraploid wheats to Ethiopia as early as 5000 years ago (Engels and Hawkes 1991:28). Archaeobotanical evidence to date, however, indicates the presence of emmer by pre-Aksumite times, approximately 2500 years ago (Bard et al. 1997; Boardman 1999; Phillipson 2000). The importance of this cereal to the Aksumite empire is evident in its depiction on coins dating from the late third to early seventh centuries A.D., where ears of emmer are shown to encircle the heads of kings (Phillipson 1993:354–355). In contrast, hexaploid[6] wheats are thought to be relatively recent introductions (Ciferri and Giglioli 1939a:224–225; Engels and Hawkes 1991:28), and several opinions exist as to sources and timing (Hailu and Haile Mariam 1990:180–181). Some suggest seventeenth-century Portuguese traders (Chiovenda 1938; Ciferri and Giglioli 1939a: 225), while others propose that Italians were responsible for introductions (Hailu 1991a:75). Recent archaeobotanical finds of bread wheat at Aksum dating to the Late Aksumite period (mid-sixth to early seventh centuries A.D.) (Boardman 1999:142, 2000:367) suggest that hexaploids may have a longer history in Ethiopia than was previously thought.

Ethiopia represents one of the few remaining regions where emmer is cultivated for human consumption on a modest scale. It is estimated that emmer constitutes almost 7% of total wheat production (National Research Council 1996: 239), a figure down from 10% suggested by Ciferri and Giglioli (1939b:386) in the late 1930s. Bale province is reported to be the largest producer of this cereal, but it is commonly grown in several other areas (Abebe and Giorgis 1991:42). Agronomic interest in emmer improvement is overshadowed by the more economically significant durum wheat (see Hailu et al. 1991). Several taxonomic treatments are available, where varieties are defined based on features such as glume color (Ciferri and Giglioli 1939a:5–16; Percival 1921; Vavilov 1931). Observations on the uniqueness of Ethiopian emmer are made by Percival (1921:192, 1927:101) who demonstrates that Ethiopian and South Asian emmers have more than two vascular bundles in the coleoptile (Vavilov 1931:164–165, 1951:178). Harlan (1969: 313) postulates that the disjunct distribution of Indo-Abyssinian emmers indicates an "ancient primary distribution." These apparently unique features led Vavilov (1931:167, 1951:38) to suggest that Ethiopian emmer should be considered a separate species distinct even from those occurring in nearby Yemen. This view is not entirely supported by Ciferri and Giglioli (1939b:385–386) who conclude that the species status of Ethiopian emmer remains unresolved.

The survival of emmer cultivation in this region can be attributed to the isolation of the highlands in recent history, resulting in Ethiopia's lack of integration into the world economy. This has allowed the preservation of indigenous agricultural systems with little domination of cash crops in rural areas (Tewolde 1993: 219). As stated earlier, the replacement of hulled wheats by free-threshing forms in the Near East began in the fourth millennium B.C.; however, this was by no means a uniform process. Evidence indicates that pockets of emmer cultivation continued along with the growing of free-threshing wheat in Western Europe and other areas until the first millennium A.D. The persistence of emmer growing in some regions such as ancient Egypt has been explained by cultural preference. The overall decline of hulled wheats relates to a variety of factors, including agricultural intensification, to which free-threshing wheats responded better, and to changes in diet with the coming of industrialization and urbanism (Nesbitt and Samuel 1996:74–89). Interviews with Tigrayan farmers indicate that emmer is declining in importance because of its relatively low productivity and onerous processing requirements. It is nevertheless still highly valued for its taste and texture in certain prepared foods.

EMMER HUSBANDRY IN SOUTH-CENTRAL TIGRAI

We collected data from several villages in south-central Tigrai, including Adi Hana and Mai Kayeh. The area corresponds to a northern emmer-growing district described and mapped by Ciferri and Giglioli (1939a:270). In this region, emmer is grown regularly for human consumption as a monocrop and intercropped with other wheats and barleys, including ***burguda*** and ***saessea*** land races of two-row hulled barley (*Hordeum vulgare* ssp. *distichum* L.), ***kinkinai*** or durum and ***shahan*** wheat (*T. aestivum* ssp. *vulgare* (Vill) MacKay). In the villages surrounding Adi Hana and Mai Kayeh, emmer is grown on a small scale primarily for household use, although farmers occasionally sell clean grain in regional markets. The market value of grain is twice that of spikelets, and it is almost always sold as dehusked grain.

Ploughing for emmer and other cereals in the region occurs anytime from January to July (D'Andrea et al. 1999:110). As in other regions of Ethiopia, the availability of oxen is a main determinant of how much ploughing is accomplished in a given year. Farmers prefer to plough each field as many as six or seven times, but two or three is more common (Bauer 1975; D'Andrea et al. 1999:110; McCann 1995:78–79). Informants used the ***maresha*** plough, which is not capable of deep ploughing (Goe 1990); thus several passes are preferred.

Emmer is sown broadcast in spikelet form (see Hillman 1984b:116), and farmers consider the idea of sowing clean grain quite humorous. When asked if sowing clean grain ever takes place, several informants laughed and replied with a rhetorical question, along the lines of, "Why would anyone do such a thing?" One informant responded with the following story:

> "One spring, a woman who had grown weary of pounding emmer gave clean grain to her husband to sow in the hopes that the ensuing harvest would produce grain free of hulls. However, the harvest produced the familiar hulled grains, so she had to pound them anyway. In the end she decided that sowing hulled emmer actually saved her work, and she was very pleased with this discovery."

Weeding is rare and culling is not practiced. During harvest, plants are normally cut about 5 cm above the ground surface using a sickle, in a manner similar to other wheats and barley. They are also harvested by uprooting using a sickle (cf. Hillman 1984b:117–118). After harvesting, plants are left to dry in small heaps in the field. The length of time before threshing varies from immediately to one or two weeks following harvest, depending upon work schedules and other obligations of the farmer, rather than on a perceived need to dry the harvest under normal conditions. There are no ceremonial activities specifically associated with emmer harvesting or threshing. The drinking of a locally-made fermented beverage known as ***sua*** and eating ***embasha*** bread with butter occurs after the threshing of any crop. There also is a short prayer recited at the end of threshing for which many informants requested privacy. If the harvest is small, farmers usually do not bother with these customs. Harvest usually occurs from October to December (mainly November), and normally there is no gleaning.

Intercropping is a worldwide feature of traditional agricultural systems. It is believed to be an ancient practice that confers several advantages to farmers (Innis 1997:1–33). This technique is commonly encountered in Tigrai and adjacent regions (Butler 2000:468–469; D'Andrea et al. 1999:111–112; Holt and Lawrence 1993: 68; Simon 1993:38; Simoons 1960:170–171). Emmer is often intercropped with other cereals, and the mixtures used are diverse, involving two or more crops. The highest number observed in the study area is three. Varying degrees of concern are expressed by farmers on proportions of different crops sown at one time, but observations of emmer are similar to those reported for ***hanfetse*** (intercropped bread wheat and barley) in Adi Ainawalid (D'Andrea et al. 1999:111). The intercropping ratio between ***shahan*** wheat and emmer varies from 2:1 (***shahan***:emmer) to 1:1. After successive replanting, emmer eventually dominates, but ***shahan*** wheat has a higher market value, and this is one reason why farmers prefer the 2:1 ratio. Another reason given is that this ratio produces the best-quality flour for making the local unleavened pancake bread known as ***taita*** (***injera*** in Amharic). Women will either add ***shahan*** or remove emmer by hand-separating to achieve this proportion, then proceed to mill the mixed grains. Flexibility in proportions sown also occurs if there is a shortage of ***shahan*** wheat seed for sowing in a given year, and the balance can be made up with emmer. Emmer is also mixed with ***burguda*** barley in this manner and for the same reasons, with ratios also varying from 2:1 (***burguda***:emmer) to 1:1. In cases where three crops are interplanted, the preferred proportions are 2:2:1 (***burguda***:***shahan***:emmer), and such mixtures can include multiple land races of barley.

Emmer cultivation is in decline in central Tigrai, and for several reasons has disappeared altogether from many areas. Although yields can be relatively high, in general, the growing of both emmer and durum wheat has been curtailed because of land and water shortages. As a result only wealthier families possess sufficient land and other resources to grow emmer. Another factor in the reduction of emmer production in Adi Hana and May Kayeh is the processing cost. Pounding is required to dehusk the grain, and informants consider this very labor intensive. Although a high regard is shown for the grain qualities, elder women describe working with emmer with a sense of displeasure or at the very least relief that they are no longer obliged to pound the spikelets (cf. Hillman 1984b: 140). The persistence of emmer growing is most certainly the result of farmers' appreciation for the foods produced (see below). In addition, Ciferri and Giglioli

(1939b:386) suggest that emmer cultivation has continued in some areas because it has adapted well to elevations of 2600 m asl and above.

POST-HARVEST TECHNOLOGY

We observed one field threshing episode and three household processing sequences. These data are supplemented by several interviews where verbal accounts and/or demonstrations by informants were provided. The post-harvest treatment of emmer and other cereals can be divided into two stages based on location of activity and individuals responsible for the work. Field processing is supervised by men with the participation of women, and includes threshing and winnowing. It culminates in the production of ***haser*** (straw), semi-clean spikelets, and ***gurdie*** (comprised of incompletely threshed ears and several impurities, such as stones, weeds, and straw fragments) (Figure 2). These activities usually take place in harvested fields away from the domestic compound. Women are responsible for household processing, which involves several operations that result in the production of clean grain and various by-products (Figures 3 and 4). The circled numbers in these figures represent samples taken from processing stages, which correspond to those listed in Tables 2 and 3. Although our original intent was to quantify processing residues to assist in the interpretation of archaeobotanical data, it was not possible to obtain sufficiently large samples for analysis because agricultural production and processing in this region is typically small scale. This situation was exacerbated during fieldwork when farmers were experiencing food shortages due to impoverished harvests. Individual sample sizes ranged from 15.1–32.9 g for field threshing and 1.1–19.0 g for household processing. As a result, statistical analysis of processing products and by-products (Hillman 1984a; Jones 1984; Jones and Halstead 1995) is not attempted here. Residues collected at each stage were identified and listed in Tables 2 and 3[7] in order of decreasing frequency of fragment counts. Although the use of these data in the direct interpretation of archaeobotanical remains is limited, observed patterns can be used to suggest possibilities for future quantitative studies. The product/by-product names and chaff terms used in Tables 2 and 3 originate from informants whose verbal descriptions corroborate extremely well with elements identified in the residues.

It is not surprising that minor differences in procedures followed by Tigrayan informants were observed. It is necessary to comment on the potential significance of this variation, as well as the degree of generalization possible from these data. The sequence in Figure 2 represents the only field processing episode observed in its entirety, but descriptions from other farmers are strongly consistent, indicating that it represents a good approximation of general practice. The household processing pathway illustrated in Figures 3 and 4 represents a summary of observations from three main informants, two of whom provided consistent answers in three separate interviews (two to four hours) separated by several months. In addition, these two informants and their extended families have grown emmer throughout their living memory. Samples obtained during the course of one processing event are described in Table 3. Although it may be premature to extend these sequences to all emmer producing regions of Ethiopia, they are certainly

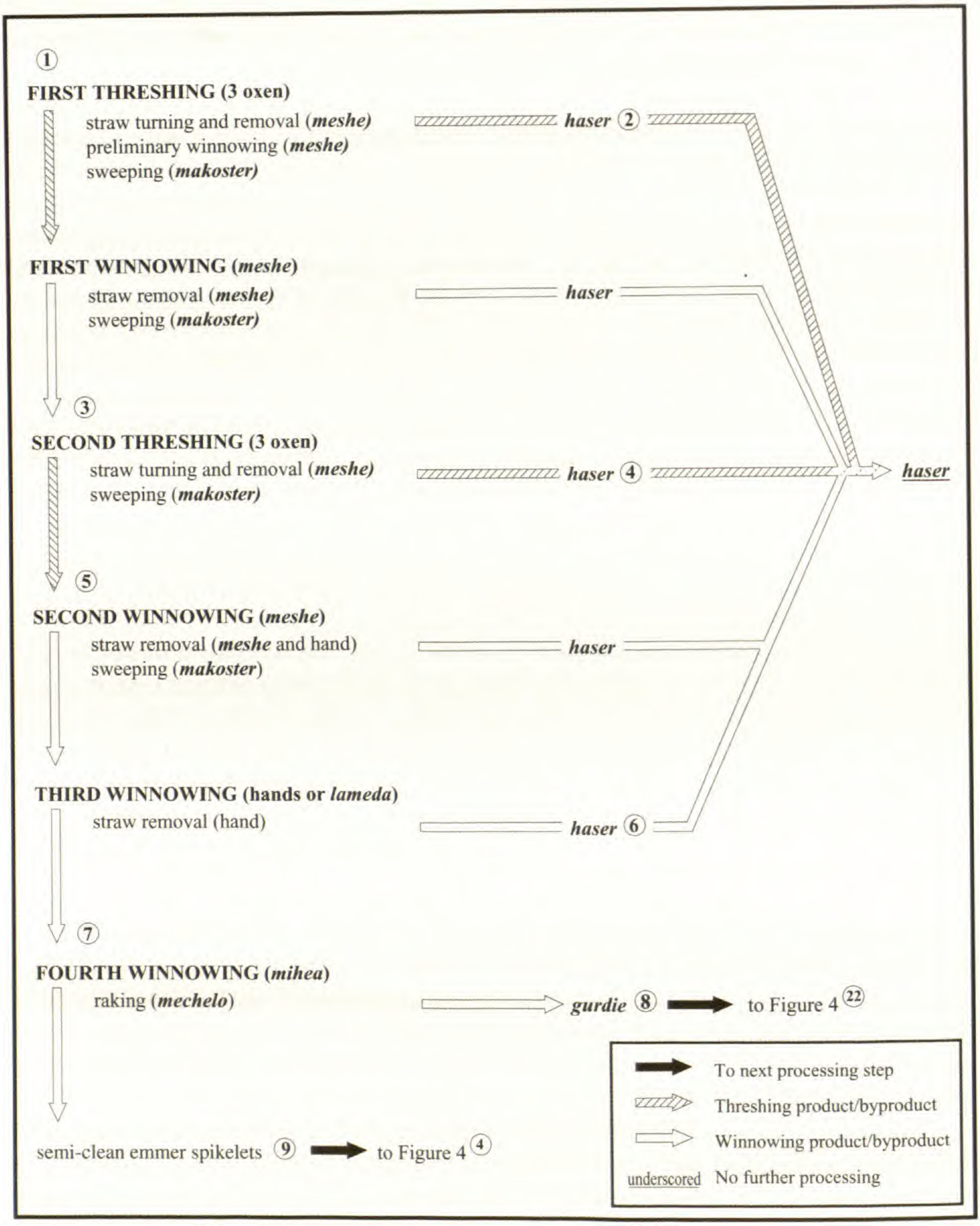


FIGURE 2.—Field processing sequence of emmer, Adi Hana.

representative of Adi Hana and Mai Kayeh. Moreover, interviews conducted in nearby villages where emmer growing has been discontinued indicate that these data may have a broadly regional applicability. At Adi Ainawalid, for example, elder men and women interviewed about their recollections of emmer processing provided detailed information that accurately reflect activities of Adi Hana and Mai Kayeh farmers documented in this study.

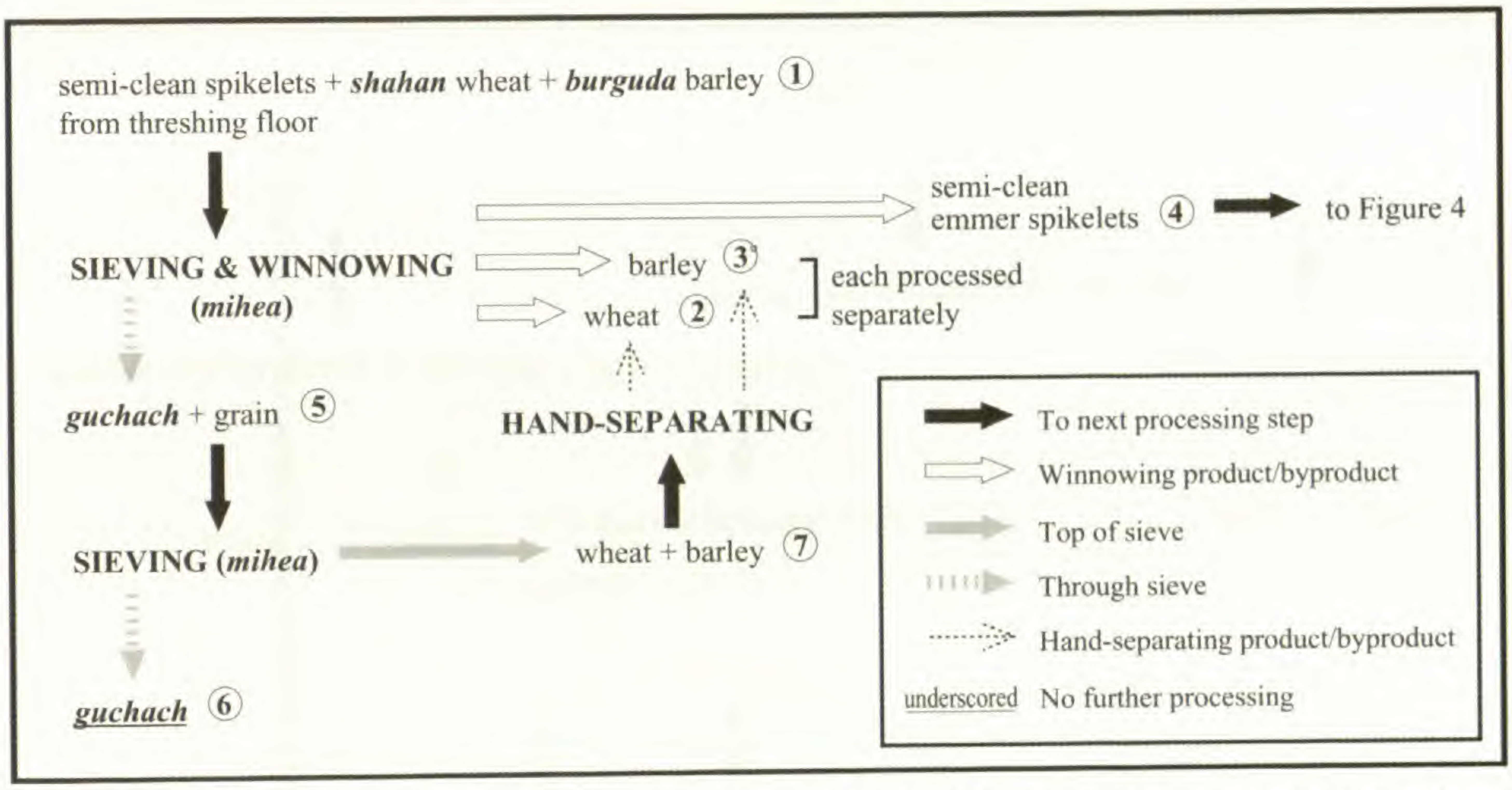


FIGURE 3.—Preliminary household processing of a mixed harvest of emmer, ***shahan*** wheat and ***burguda*** barley, Adi Hana.

Tools used in processing will be described more fully elsewhere (D'Andrea in prep.), but include a flat winnowing basket with coarse apertures that also acts as a sieve (***mihea***), fine and coarse sieves (***monfit***), a flat circular winnowing tray without apertures (***sefi***), wooden mortar (***mogu***) (Figure 5), two- and three-pronged wooden winnowing forks (***mese***), and brush-like instruments used in sweeping (***makoster***) and raking (***mechelo***). All implements are made from locally available grasses and woods, while brushes are fashioned from available dried shrubbery.

Field Processing.—One complete threshing of a small emmer harvest was observed in Adi Hana. The processing steps are summarized in Figure 2, while Table 2 provides a description of residues produced at each stage. The crop was harvested the previous day from 1/2 ***tsumdi*** or 1/8 hectare of land which took the farmer one day to harvest. It was sown with 70 ***menelik*** or approximately 46 liters of spikelets, which were obtained from the previous year's crop. This harvest produced an estimated 25 kg of spikelets, and was characterized by the farmer and other informants as a very poor yield.

Threshing operations are supervised by men, who are assisted by younger children of both sexes and occasionally by women. Threshing of all crops is accompanied by singing threshing songs and energetic exclamations of "hey-ho, hey-ho, hey-ho. . ." This is thought to focus the energy of the farmer and to spur on the oxen. Threshing takes place on a flattened circular area, the surface of which is prepared by sweeping with a ***makoster.*** Occasionally, the threshing floor is coated with a dung and water mixture, which after drying in the sun, produces a uniform surface. This is done specifically for tef, which is threshed first; other crops follow (D'Andrea et al. 1999:112). The harvest is spread evenly on the floor and first threshing is conducted with three or more oxen (Figure 6). Farmers use a two-pronged wooden ***mese*** (winnowing fork) to turn the straw as threshing

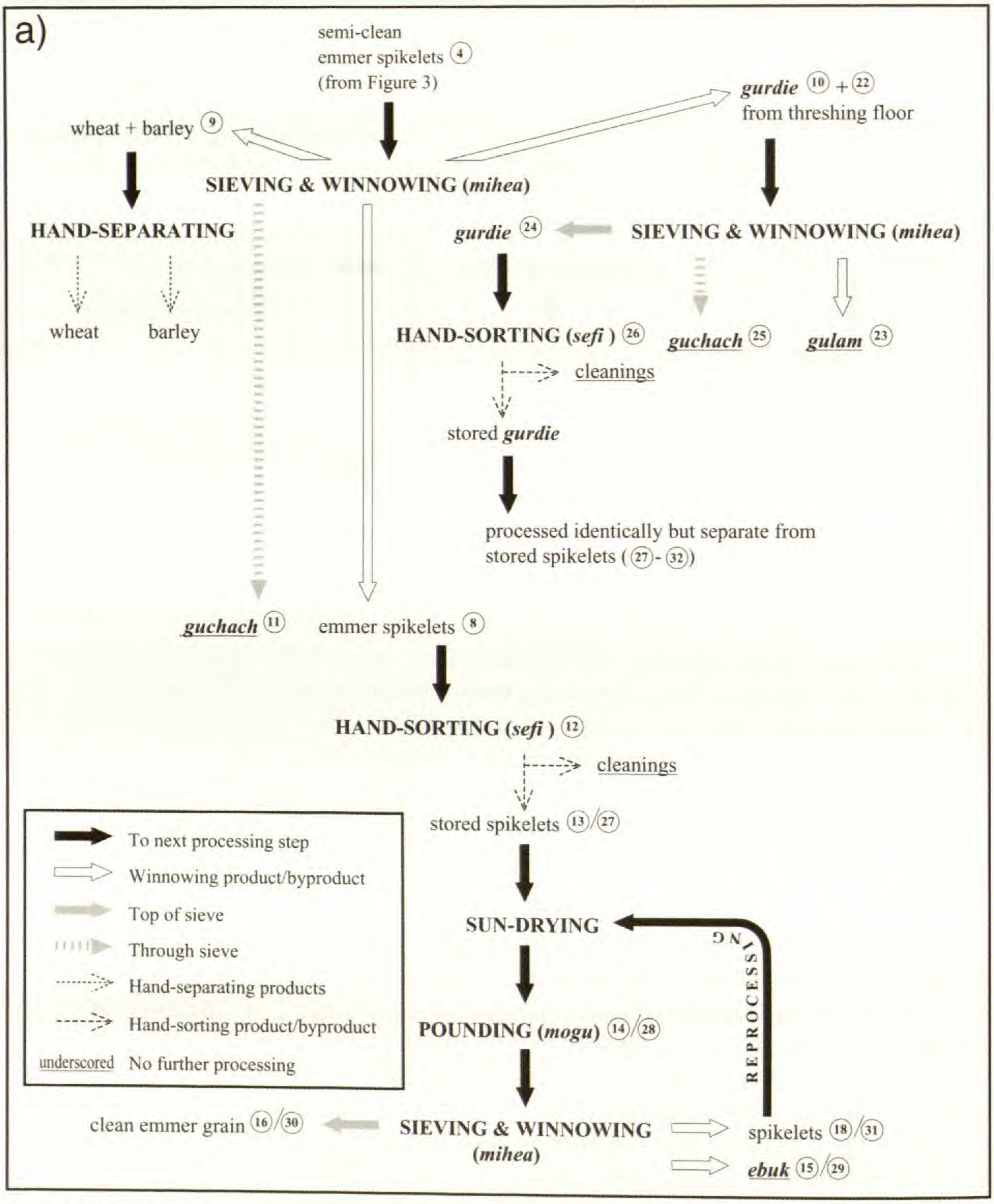
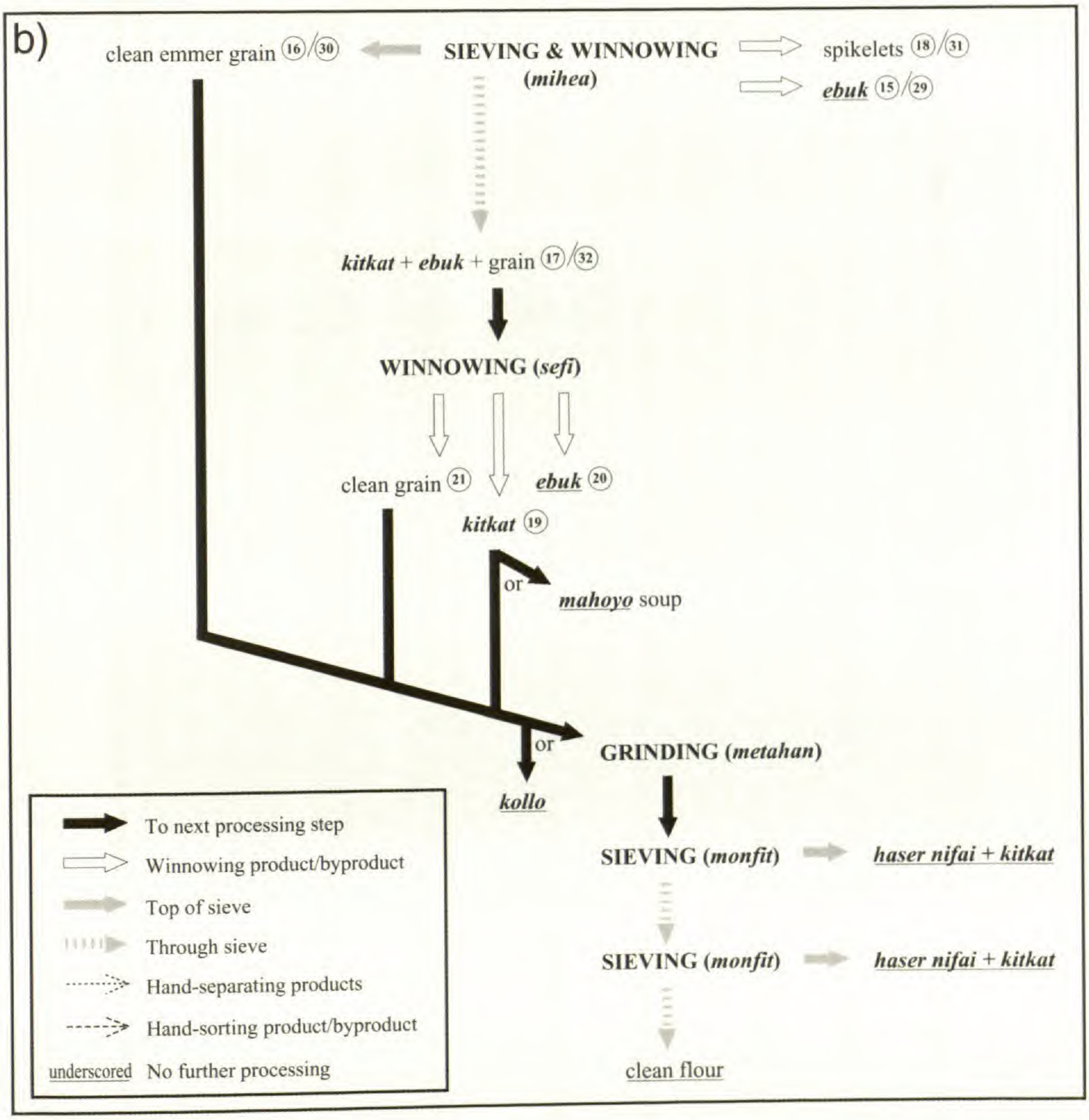


FIGURE 4.—Household processing sequence of emmer, Adi Hana. The sieving and winnowing step at the bottom of page 190 is repeated at the top of page 191.

progresses. Toward the end of first threshing, while oxen continue trampling, some preliminary winnowing takes place as the harvest is tossed into the wind using a two-pronged fork. Several farmers stated that normally only one threshing is necessary, and in general emmer is much easier to thresh than other cereals. However, during the 1997 harvest season, emmer required two or more threshings because unseasonable rains resulted in high moisture levels in all harvested crops. A similar observation is made by Hillman (1984b:125) concerning the processing



of glume wheats in Turkey, where one threshing is sufficient except when the harvest is damp or unripe. First threshing ends with sweeping the threshing floor and consolidating the harvest using a ***makoster***. First winnowing proceeds with a two-pronged ***mese*** which is used to toss the harvest into the wind and to remove straw which is piled along the periphery of the threshing floor (Figure 7). If a three-pronged fork is available, it is used at this stage because it is more effective in picking up smaller straw fragments. First winnowing ends by consolidating the harvest by sweeping with a ***makoster***.

Oxen are returned to the threshing floor for second threshing (if necessary) where straw continues to be turned over and removed. At the end of this stage, the harvest is again consolidated in the center of the floor by sweeping. It is followed by second winnowing using a two- or (preferably) three-pronged winnowing fork. Straw is removed by hand, and the harvest is consolidated by sweep-

TABLE 2.—Field processing residues: emmer (see Figure 2 for processing pathway).

Sample	Wt. (g)	Product/by-product	Description
1	24.9	unthreshed emmer	**complete emmer plants with roots attached**†
2	18.4	straw removed during first threshing	**straw from middle to bottom half of emmer plants,** partially threshed spikelets‡; spikes/fruit (*Cynodon dactylon* (L.) Pers., *Brassica,* grass pea)
3	15.1	floor sample at end of first winnowing	**straw fragments,** threshed spikelets, partially threshed spikelets, complete ears; seeds (*Avena sterilis,* barley, *Scorpiurus mucronatus* L., *Brassica,* Lamiaceae); spikes/fruits (*C. dactylon, Comicarpus*)
4	16.8	straw removed during second threshing	**straw from middle to bottom half of emmer plants,** straw with 1–2 basal spikelets attached, partially threshed spikelets, threshed spikelets; spikes/fruits (*C. dactylon, A. sterilis,* indeterminate flower head, *Brassica, Polypogon, Eragrostis*)
5	18.4	floor sample at end of second threshing	**threshed spikelets,** partially threshed spikelets, straw fragments; seeds (*A. sterilis,* emmer, barley, grass pea, fenugreek, wheat); spikes/fruits (*Comicarpus, C. dactylon, Sonchus oleraceus* L.)
6	32.8	straw removed during third winnowing	**straw from middle of plant,** threshed spikelets, partially threshed spikelets, straw with 1–2 basal spikelets attached; spikes/fruits (*A. sterilis, Comicarpus, S. mucronatus, C. dactylon,* Lamiaceae, fenugreek, *Polypogon, Ammi majus* L., *S. oleraceus*)
7	18.0	floor sample at end of third winnowing	**threshed spikelets, partially threshed spikelets, straw fragments**; seeds (*A. sterilis,* wheat, barley, emmer, fenugreek; spikes/fruits (*C. dactylon, S. oleraceus*)
8	18.1	*gurdie*	**partially threshed spikelets, straw with 1–2 basal spikelets attached,** threshed spikelets, straw fragments; seeds (*A. sterilis, S. mucronatus,* fenugreek)
9	32.9	semi-clean spikelets	**threshed spikelets,** partially threshed spikelets, straw with 1–2 basal spikelets attached; seeds (*A. sterilis,* fenugreek, barley, wheat, emmer, grass pea, lentil, Fabaceae, chickpea, *Lolium temulentum, S. mucronatus*); spikes/fruits (*Comicarpus*)

* Residues are listed in the following order: all emmer elements; loose seeds; spikes/fruits. Within each category, items are listed in decreasing frequency based on raw counts.

† Dominating elements, where present, are in boldface.

‡ Partially threshed spikelets represent two or more attached spikelets.

TABLE 3.—Household processing residues: intercropped emmer, ***shahan*** wheat and ***burguda*** barley (see Figures 3, 4 for processing pathway).

Sample	Wt. (g)	Product/by-product	Description*
1	15.3	semi-clean spikelets	**barley**†, **wheat, threshed spikelets,** *A. sterilis,* empty glumes, partially threshed spikelets‡, *S. mucronatus, Brassica,* Asteraceae flower, cf. Zygophyllaceae, dung/stones
2	14.5	wheat	**wheat,** barley, *A. sterilis, Brassica,* dung/stones
3	12.8	barley	**barley,** wheat, *A. sterilis,* threshed spikelets, dung/stones
4	18.4	semi-clean spikelets	**threshed spikelets, barley,** *A. sterilis,* wheat, *S. mucronatus,* cf. Zygophyllaceae, partially threshed spikelets, Asteraceae flower
5	18.3	***guchach*** + grain	**wheat, barley, *A. sterilis,*** threshed spikelets, indeterminate flowers, *L. temulentum, S. mucronatus,* flax, Solanaceae, Asteraceae flower, dung/stones
6	13.3	***guchach***	**barley, wheat, *A. sterilis,*** threshed spikelets, straw fragments, Asteraceae flowers, empty glumes, *S. mucronatus, L. temulentum,* flax, Apiaceae, dung/stones
7	16.5	wheat + barley	**wheat, barley,** *A. sterilis,* flax, dung/stones, diseased rachis/ears
8	13.4	emmer spikelets	**threshed spikelets,** barley, *A. sterilis,* wheat *S. mucronatus,* diseased rachis/ears, dung/stones
9	16.5	wheat + barley	**barley,** wheat, threshed spikelets, *A. sterilis,* cf. Zygophyllaceae, dung/stones
10	9.7	***gurdie***	**threshed spikelets, partially threshed spikelets,** straw fragments, barley, *A. sterilis,* straw with 1–2 basal spikelets attached; *S. mucronatus,* Asteraceae flower, *Medicago,* cf. Zygophyllaceae, diseased rachis/ear, dung/stones
11	10.6	***guchach***	**barley, *A. sterilis,*** threshed spikelets, wheat, straw fragments, *S. mucronatus,* Asteraceae flowers, partially threshed spikelets, *L. temulentum,* cf. Zygophyllaceae, dung/stones
12	3.2	cleanings from hand-sorting	**diseased rachis/ears,** *S. mucronatus,* cf. Zygophyllaceae, barley, indeterminate plant, straw fragments, Asteraceae flowers, *A. sterilis,* barley rachis, *Brassica* siliques, sorghum, dung/stones
13	8.1	stored spikelets	**threshed spikelets,** barley, *A. sterilis,* partially threshed spikelets, wheat, *S. mucronatus*
14	17.0	pounding product/by-product	**threshed spikelets,** empty glumes, broken emmer, emmer, barley, *A. sterilis,* wheat

TABLE 3.—(continued)

Sample	Wt. (g)	Product/by-product	Description*
15	1.1	***ebuk***	**empty glumes,** threshed spikelets, *A. sterilis,* straw fragments, dung/stones
16	8.2	clean emmer grain	**emmer, barley,** broken emmer, wheat, *A. sterilis,* threshed spikelets, cf. Zygophyllaceae, empty glumes
17	7.0	***kitkat*** + ***ebuk*** + grain	**empty glumes, broken emmer,** emmer, broken barley, barley, wheat, *A. sterilis,* threshed spikelets, *S. mucronatus,* Trifoleae, diseased rachis/ears
18	9.2	spikelets for reprocessing	**threshed spikelets,** empty glumes, *A. sterilis,* barley, broken emmer, emmer, broken barley, cf. Zygophyllaceae
19	7.5	***kitkat***	**broken emmer,** emmer, wheat, broken barley, *A. sterilis,* barley, diseased rachis/ears, *S. mucronatus,* Trifoleae
20	4.9	***ebuk***	**empty glumes,** broken emmer, broken barley, *A. sterilis,* indeterminate crushed grain, threshed spikelets, barley, *L. temulentum,* wheat, *S. mucronatus,* cf. Zygophyllaceae, dung/stones
21	7.0	clean emmer grain	**emmer, broken emmer,** threshed spikelets, broken barley, barley, *A. sterilis,* wheat empty glumes, *S. mucronatus,* straw fragments, Trifoleae, Poaceae
22	12.6	***gurdie*** from threshing floor	**threshed spikelets,** partially threshed spikelets, straw fragments, barley, *A. sterilis,* barley rachis, *S. mucronatus, Medicago,* wheat, *L. temulentum,* dung/stones, indeterminate plant
23	5.0	***gulam***	partially threshed spikelets, straw fragments, indeterminate plant, barley, barley rachis *A. sterilis, S. mucronatus, Medicago,* straw with 1–2 basal spikelets attached, *Trifolium* flower, *L. temulentum,* Poaceae
24	11.9	***gurdie***	**threshed spikelets,** partially threshed spikelets, barley, *A. sterilis,* empty glumes, *S. mucronatus,* wheat, straw fragments, cf. Zygophyllaceae, *Medicago,* indeterminate plant, dung/stones
25	5.2	***guchach***	**barley, *A. sterilis,*** straw fragments, empty glumes, threshed spikelets, wheat, indeterminate plant, broken emmer, *L. temulentum, S. mucronatus,* cf. Zygophyllaceae, partially threshed spikelets, *Brassica, Medicago,* Asteraceae flower, dung/stones
26	5.3	cleanings from hand-sorting	*S. mucronatus,* dung/stones, *Medicago,* disease rachis/ears, indeterminate plant, barley, cf. Zygophyllaceae, Asteraceae flower, straw fragments, threshed spikelets, empty glumes, *Brassica*

TABLE 3.—(continued)

Sample	Wt. (g)	Product/by-product	Description*
27	19.0	stored spikelets (*gurdie*)	**threshed spikelets,** partially threshed spikelets, barley, *A. sterilis,* straw fragments, *S. mucronatus,* wheat, barley rachis, empty glumes, indeterminate plant, broken emmer, dung/stones
28	12.7	pounded product/by-product (*gurdie*)	**threshed spikelets, empty glumes,** broken emmer, emmer, broken barley, *A. sterilis,* barley, wheat, partially threshed spikelets, *S. mucronatus,* straw fragments, cf. Zygophyllaceae, *Medicago,* Trifoleae, Poaceae, indeterminate plant
29	6.6	***ebuk*** (*gurdie*)	**empty glumes, threshed spikelets,** broken emmer, *S. mucronatus, A. sterilis,* straw fragments, broken barley, straw with 1–2 basal spikelets attached, *L. temulentum,* indeterminate plant, cf. Zygophyllaceae, dung/stones
30	9.4	clean emmer grain (*gurdie*)	**emmer, broken emmer,** barley, wheat, threshed spikelets, empty glumes, *A. sterilis,* cf. Zygophyllaceae, dung/stones
31	12.0	spikelets for reprocessing (*gurdie*)	**threshed spikelets,** empty glumes, broken emmer, barley, *A. sterilis,* emmer, partially threshed spikelets, *Medicago,* cf. Zygophyllaceae, straw fragments
32	8.6	***kitkat*** + ***ebuk*** + grain (*gurdie*)	**empty glumes,** broken emmer, broken barley, emmer, barley, *A. sterilis,* wheat, *S. mucronatus,* indeterminate plant, Trifoleae, straw fragments, barley rachis, Asteraceae flower, diseased rachis/ears

* All elements are listed in decreasing frequency based on raw counts. All plant remains refer to seeds unless specified otherwise.
† Dominating elements within each sample, where present, are in boldface.
‡ Partially threshed spikelets represent two or more attached spikelets.

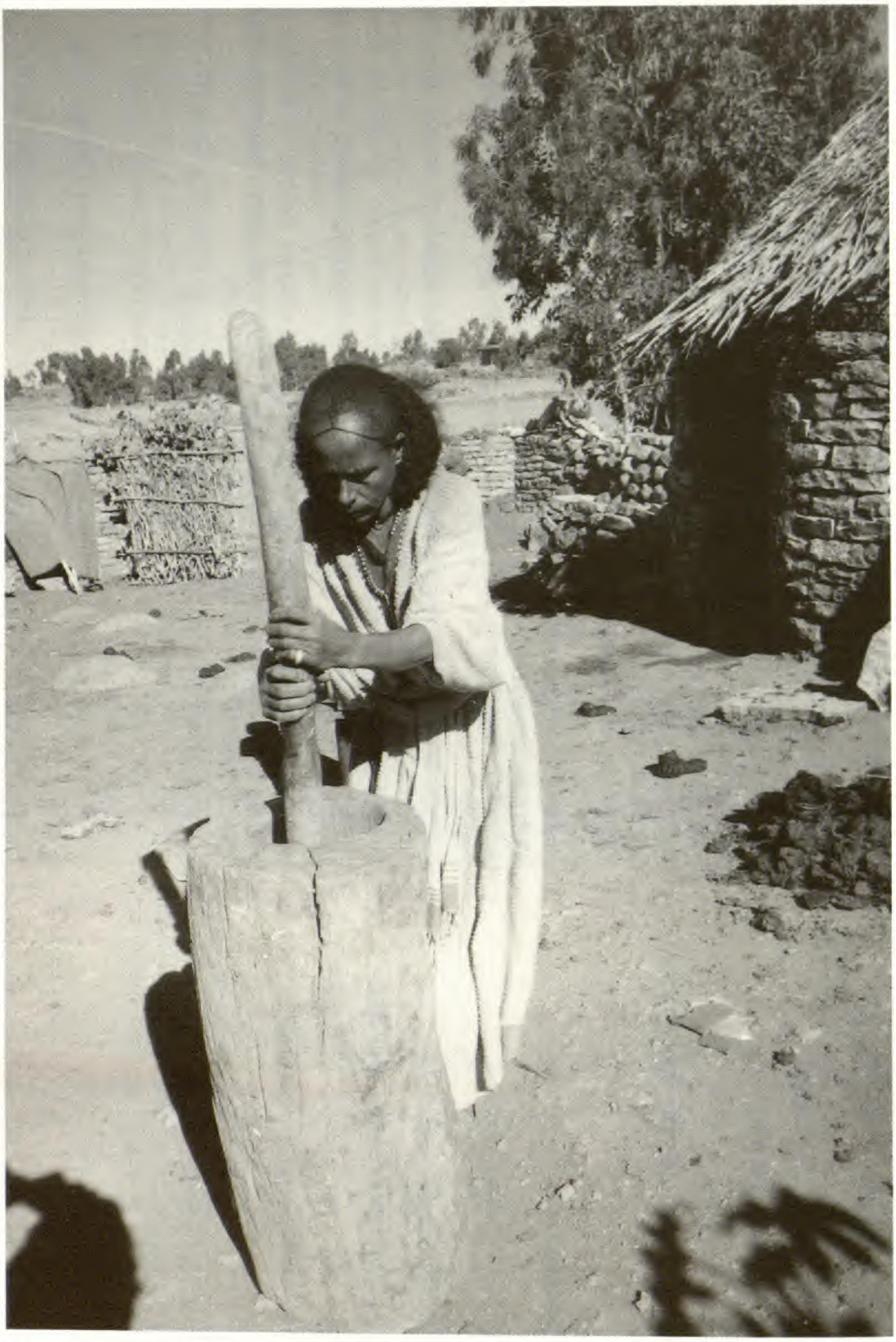


FIGURE 5.—Wayzaro Halufti Tesfaye pounding grain with a ***mogu,*** Adi Ainawalid.

ing with a ***makoster*** in preparation for third winnowing. If the harvest is large, a ***lameda*** (winnowing shovel) is employed at this stage, but in small harvests, winnowing by hand is practiced. In this activity, two people facing each other and joining hands beneath the harvest lift a large portion and let it fall into the wind (Figure 8). Larger fragments of straw are removed by hand. This winnowing method has not been previously reported in the literature (e.g., Hillman 1984b;

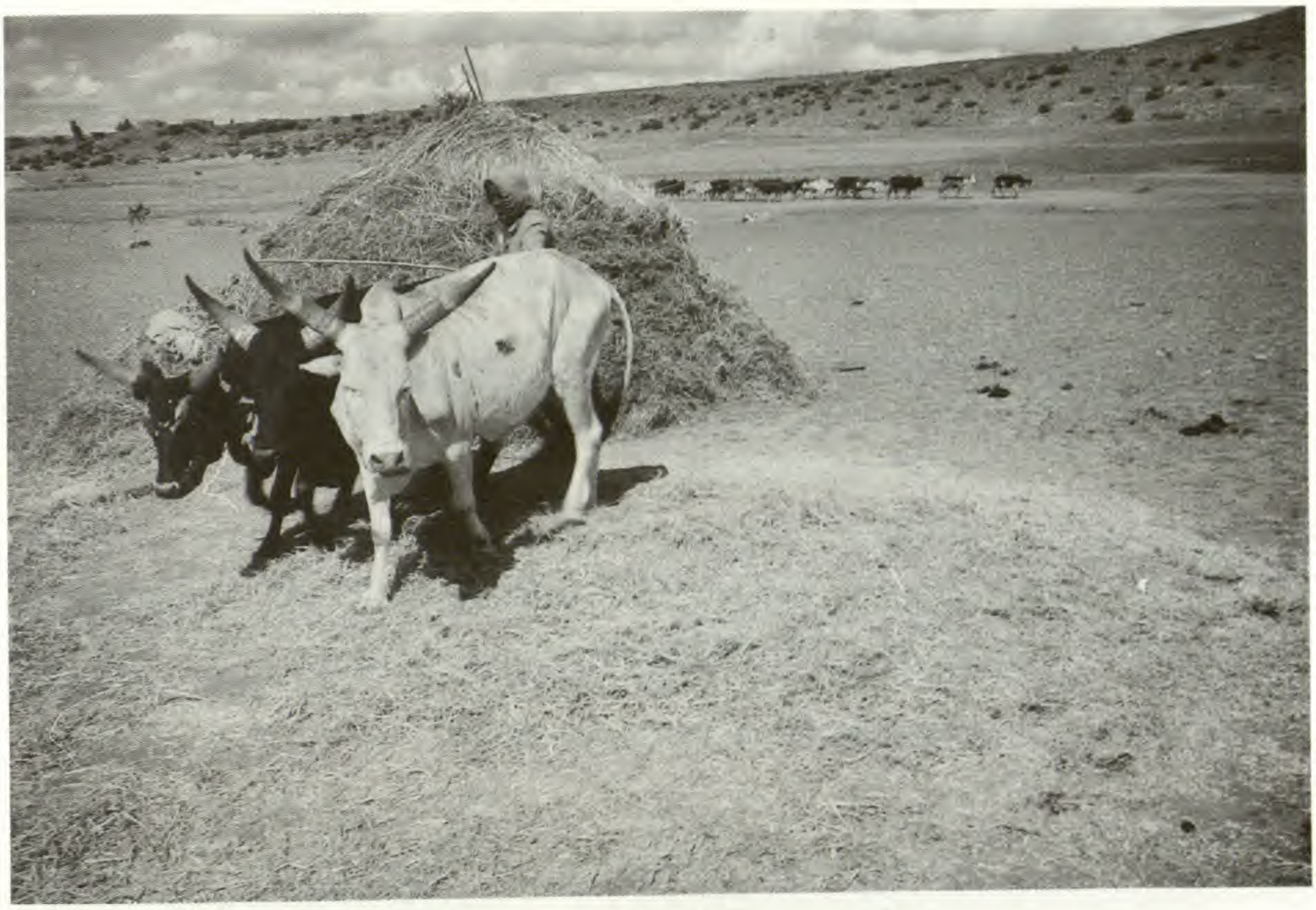


FIGURE 6.—First threshing of emmer, Adi Hana.

FIGURE 7.—First winnowing using a ***meshe***, Adi Hana.

FIGURE 8.—Third winnowing of emmer by hand, Adi Hana.

Murray 2000; Samuel 1993), and may represent a technique employed with particularly small harvests. Fourth winnowing proceeds using a ***mihea***, where basketfuls of harvest are lifted and dropped into the wind, with spikelets accumulating at the feet of the winnower (Figure 9). During this activity, dust and small chaff elements pass through the ***mihea*** as well, but the activity is primarily winnowing. After each basketful, the surface of the spikelet pile is raked using a ***mechelo***. This action produces two accumulations which are bagged separately: semi-clean spikelets at the foot of the winnower, and ***gurdie*** which is raked aside by the ***mechelo***.

Field processing results in the production of one by-product (straw) and two products (semi-clean spikelets and ***gurdie***), all of which are transported to the residential compound by donkey or human carriers. Emmer straw is used mainly as fodder, and has no special uses to distinguish it from wheat and barley straw. It is stored outdoors in a designated area next to the residential compound, and is subjected to no additional processing prior to being fed to livestock. Wheat and especially barley straw are preferred in the production of dung cakes which constitute the most important domestic fuel. Straw is added only during the rainy season because dung tends to be more viscous at this time, and the added straw facilitates drying and improves burning quality. Unlike India and other regions where dung fuel production takes place only during the dry season (Reddy 1999: 63), this activity continues throughout the year in the Ethiopian highlands. Chopped wheat and barley straw is not used in making mortar, but can be com-

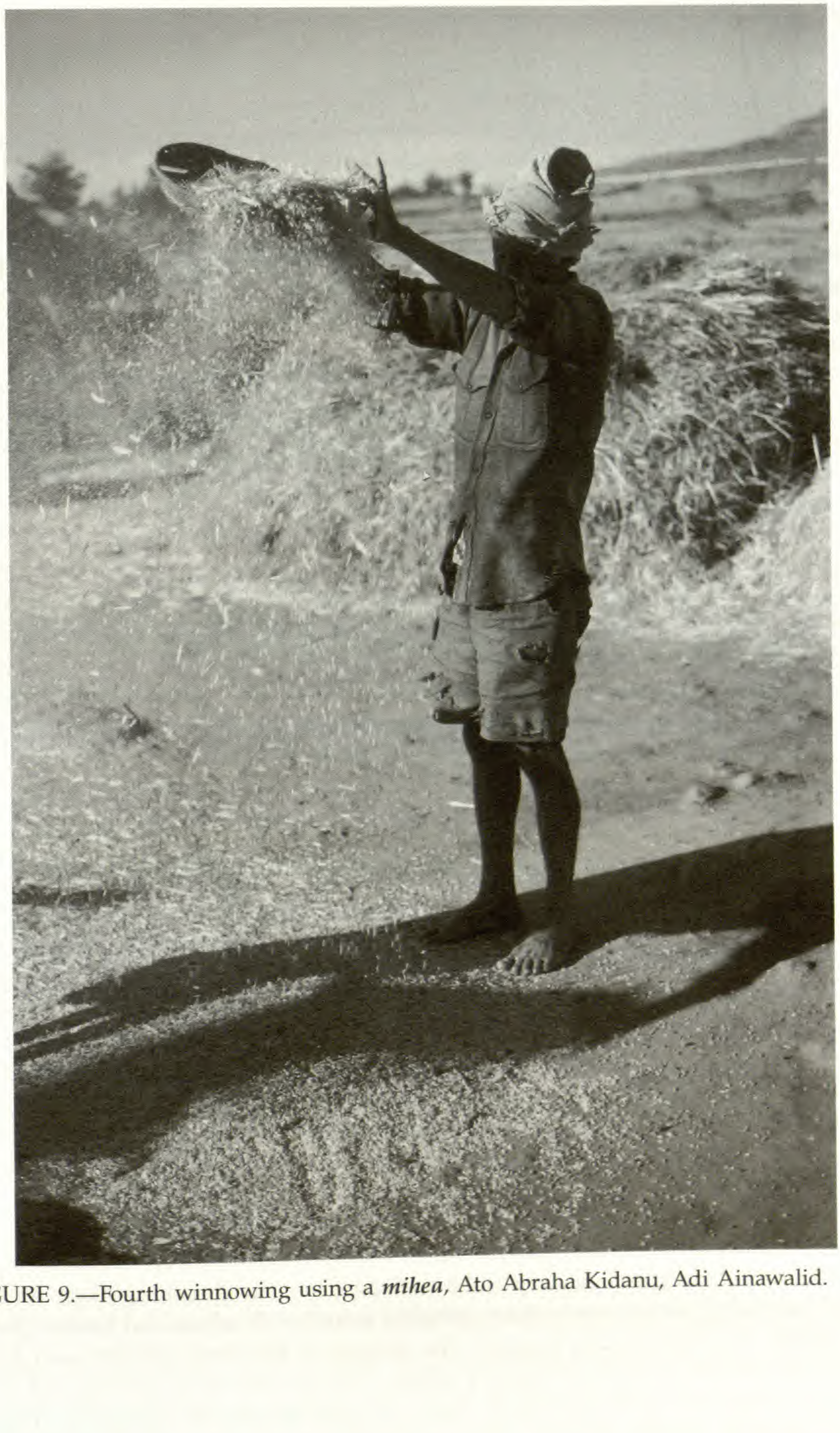


FIGURE 9.—Fourth winnowing using a *mihea*, Ato Abraha Kidanu, Adi Ainawalid.

bined with clay to plaster interior walls of houses, especially in the first layers applied to new walls.

Household Processing.—The processing of semi-clean spikelets and ***gurdie*** takes place entirely in the household, under the supervision of women with virtually no involvement by men. When semi-clean spikelets arrive from the threshing floor, they are cleaned and processed in the following steps with a remarkable degree of consistency: 1) sieving/winnowing (***mihehai***), 2) hand-sorting,[8] 3) sun-drying, 4) pounding, 5) sieving/winnowing (***mihehai***), hand-sorting and reprocessing if necessary, 6) winnowing (***mentertar***), 7) grinding (milling) into flour or whole grains used in food preparation, 8) flour sieving, 9) food preparation from flour.

In this sequence, slight variation occurred in the order of sieving/winnowing and hand-sorting in steps 1, 2 and 5. Observed differences depend on several factors including personal preference, economic conditions, and effectiveness of the previous processing operation. Personal preference introduces variation and can be related to skill level as well as available equipment. For example, a ***mihea*** is normally used in the initial stages of household winnowing, but a ***sefi*** can be substituted if necessary. In terms of economic situation, informants mentioned that at several stages, products used as fodder can be further processed to extract more grain, in the case of food shortages. In addition, fine chaff removed at various stages in household processing is sometimes used as fodder and other times discarded on compound floors, depending on fodder availability. Such fine cleanings are not used in making dung cakes for fuel. Finally, success of cleaning in previous stages can determine the type of operation; in particular, the most common step added for this reason was extra hand-sorting or winnowing. Except for a reversal in pounding and drying steps, this processing pathway compares reasonably well with reconstructions of emmer processing from ancient Egyptian archaeological and textual data (Samuel 1999:130, 2000:541), and at a general level with ethnographic studies in Turkey (Hillman 1984b). Further comparisons are discussed below.

The particular case illustrated in Figures 3 and 4 involved the processing of a harvest of a mixed crop of emmer, ***shahan*** wheat, and ***burguda*** barley. Descriptions of residues produced at each processing stage are summarized in Table 3. These mixtures can be processed together entirely (including grinding to produce flour), but more commonly, grains are separated at an early stage in the processing sequence, as illustrated in Figure 3. The subsequent treatment of emmer spikelets depicted in Figure 4 is not affected by the early removal of these other cereals. The overall character of residues, however, certainly is influenced by the presence of barley and wheat grains, which would not be expected to occur in large quantities in a monocropped harvest of emmer.

The mixed crop arrives in the household from the threshing floor in two forms (excluding straw): semi-clean spikelets mixed with wheat and barley grains and ***gurdie***. As illustrated in Figure 3, the mixture of threshed spikelets and grain is first sieved and winnowed using a ***mihea***. This simultaneous sieving and winnowing action has no English term, but is termed ***mihehai*** in Tigrinyna (Figure 10). In ***mihehai***, women employ a sideways and circular motion which is designed

FIGURE 10.—The ***mihehai*** technique, Wayzaro Yalemser Asbaha, Adi Hana.

to make fine impurities such as small weed seeds and dust fall through the ***mihea.*** As such this technique is roughly equivalent to fine sieving where products are retained by the sieve allowing impurities to pass through (Jones 1984:46). Materials are also tossed on the ***mihea*** and air is blown from the winnower's mouth,

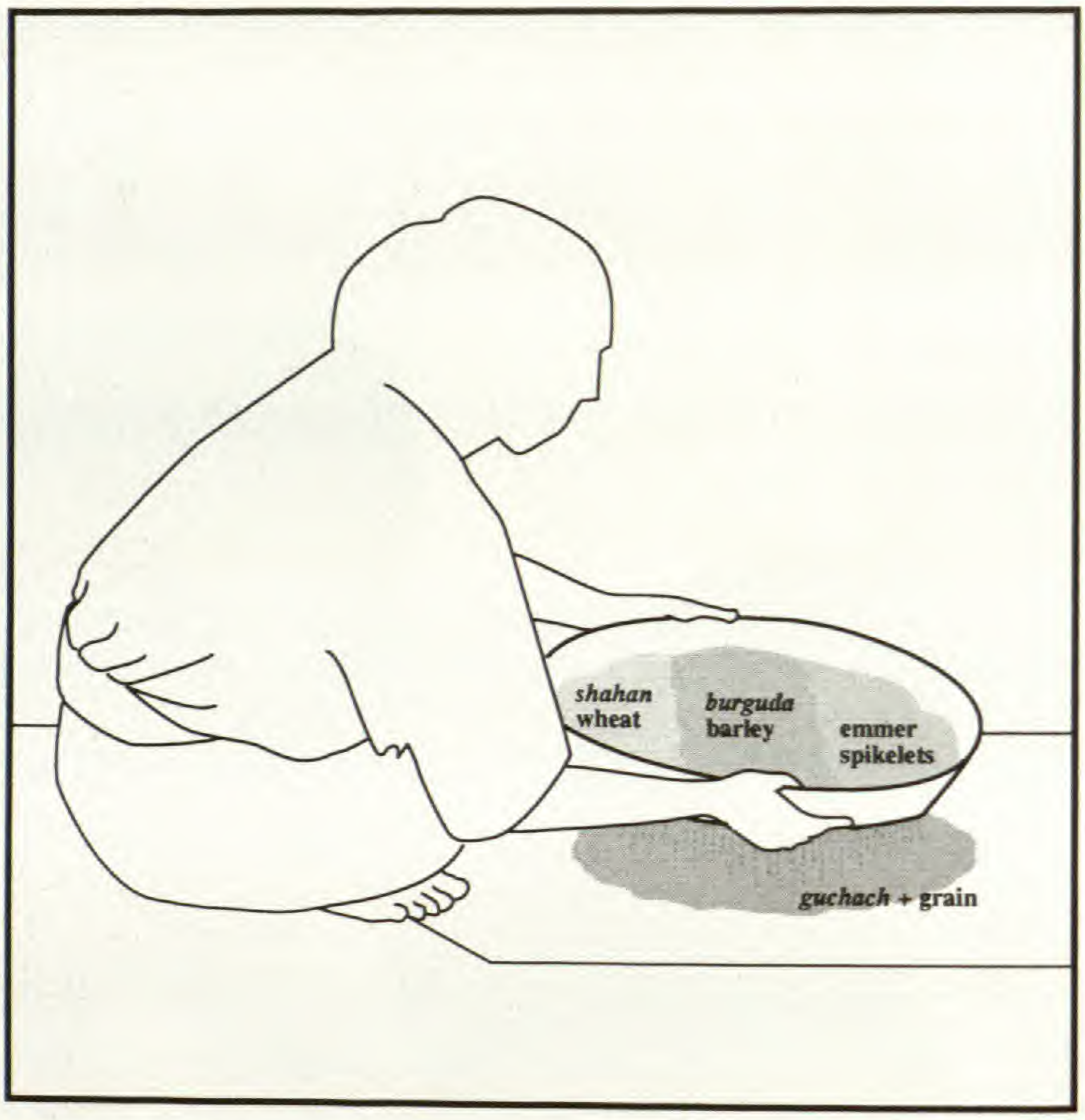


FIGURE 11.—Schematic drawing of a woman separating four components using the *mihehai* technique.

actions which further encourage the separation of components and removal of fine particles. This activity may or may not involve tossing materials from the *mihea* into other containers. ***Mihehai*** is sometimes accompanied by hand-sorting, which occurs if the harvest contains excessive amounts of impurities such as stones, soils, and large straw fragments. These elements are discarded on the compound floor. When the ***mihea*** is employed at this stage, four fractions are produced: 1) a ***guchach*** and grain mixture that falls through the sieve; and remaining on top and sequentially winnowed are separate accumulations of 2) spikelets, 3) ***burguda*** barley, and 4) ***shahan*** wheat grain. These last three components are gradually sorted out on the ***mihea*** through the circular and sideways movements of ***mihehai*** very skillfully executed by the winnower, after which they are tossed into separate containers. Figure 11 is a schematic drawing of ***mihehai*** at this stage, with the four fractions described in samples 2–5 of Table 3 and illustrated in Figure 12. The ***guchach*** and grain passing through is further processed using a ***mihea,*** but this sieving step is not usual. Because this particular harvest was relatively impoverished, many grains were small and easily broken so that a greater quantity than normal passed through the ***mihea.*** The ***guchach*** and grain mixture is sieved to produce two fractions: 1) ***guchach*** which falls through, and is used as fodder and 2) a ***shahan*** wheat and ***burguda*** barley mixture remaining on top which is hand-separated and combined with previously winnowed wheat and barley. The ***guchach*** can be further processed by drying, pounding, and winnowing to extract more grain, in situations of extreme food shortage.

FIGURE 12.—Four components separated using the ***mihehai*** technique, Wayzaro Yalemser Asbaha, Adi Hana. The ***mihea*** is partially visible at the top of the photograph, with ***guchach*** + grain detectable beneath. Emmer spikelets are in the basket to left, while the ***sefi*** in the foreground contains ***shahan*** wheat (top right) and ***burguda*** barley (bottom left). The diameter of the ***sefi*** is approximately 42 cm. Processing residue contents are described in samples 2–5 of Table 3.

As illustrated in sample 6 of Table 3, grains of wheat, barley and the weed *Avena sterilis* L. are the main components of ***guchach.***

Reports of poor harvests by informants are corroborated by the presence of large quantities of single-seeded emmer spikelets in residues collected during the processing episode summarized in Tables 2 and 3 (cf. Willcox 1999:487). A total of 53% (1521) of completely threshed spikelets (n = 2887) examined in this sample are single-seeded. In addition, 6% (181) of completely threshed spikelets display a barrel-type disarticulation pattern where the rachis segment adheres to the inner side of the spikelet. This is a pattern typically observed in spelt wheat (Zohary and Hopf 2000:30). The occurrence of this feature in emmer may be related to a combination of factors including threshing practices and depauperate plant populations (Laura Morrison, personal communication, 2000). Farmers attribute these unusual traits to water deficiencies and other ecological stresses experienced during the growing season.

Figure 4 illustrates the processing of spikelets extracted from the mixed crop and ***gurdie*** originating from the threshing floor. This ***gurdie*** does not normally undergo preliminary sorting for wheat and barley grains. Beginning with semi-clean spikelets, they are first sieved and winnowed using a ***mihea.*** This produces four fractions: 1) ***guchach*** falls through the sieve and is used as fodder; 2) a wheat and barley grain mixture remaining on the sieve, which is tossed and later hand-separated and added to the previous wheat and barley (Figure 3); 3) ***gurdie*** is tossed into a separate basket and processed later with other ***gurdie*** arriving from the threshing floor; and 4) spikelets are tossed into a different container and further processed by hand-sorting, the cleanings of which are discarded on the compound floor. At this point, spikelets are stored in the living quarters and processed in small amounts as needed. Large-scale processing and storage of clean emmer grain for household consumption is not practiced in this region.

When required, spikelets are sun-dried for up to two days and are never parched before pounding. None of the informants knew of anyone who parched or dried spikelets using an oven, and water is never added before pounding. The same applies to the processing of hulled barley. Pounding occurs in a wooden mortar (***mogu***) with a wooden, stone or metal pounder (Figure 5). When asked if a stone quern (***metahan***) is ever used to dehusk emmer, informants unanimously agreed that this never took place, and even though some farmers used mortars made of stone, wooden ones are preferred. Farmers maintain that using stone mortars results in too many broken grains, a problem that is avoided by the use of a wooden mortar. The action of pounding emmer spikelets in a ***mogu*** is very similar to that reported in an experimental study by Bower (1992:238). Free grains accumulate at the bottom of the mortar while chaff rises to the surface and is thrown clear by pestle movements. The category "empty glumes" in pounded samples 14 and 28 (Table 3) is dominated by heavy chaff elements (glume bases and spikelet forks): sample 14 produced 30% (n = 31) spikelet forks and 70% (n = 71) glume bases while sample 28 (***gurdie*** from threshing floor) consisted of 48% spikelet forks and 52% glume bases.

After pounding, the mixture is sieved and winnowed using a ***mihea.*** This produces four fractions: 1) a ***kitkat, ebuk,*** and grain mixture which falls through the sieve; and remaining on top and tossed into separate baskets using the ***mihehai*** technique are 2) clean grain which is ready for grinding into flour (hand-sorted beforehand, if necessary), 3) ***ebuk*** which is tossed off the ***mihea*** and used as fodder or discarded, and 4) unhusked spikelets which are tossed into a separate basket, later sieved with a ***monfit*** or winnowed using a ***sefi*** if necessary (with cleanings discarded), and then reprocessed. It is at this point that the majority of heavy chaff elements are removed. ***Ebuk*** in samples 15 and 29 (Table 3, Figure 4) consists almost entirely of spikelet forks with glumes attached. Similarly, experiments involving pounding emmer in wooden mortars have revealed a relatively high occurrence of intact spikelet forks (Meurers-Balke and Lüning 1999:249).

The ***kitkat, ebuk,*** and grain mixture that falls through the ***mihea*** is winnowed using a ***sefi.*** This produces three fractions: 1) ***ebuk*** which is tossed and used as fodder for chickens; and remaining on top and removed by hand are 2) clean grain and 3) ***kitkat*** which is broken grain that is especially good for making ***mahoyo*** soup or is mixed with other clean grain and ground into flour. The clean grain removed at this point (sample 21) frequently requires hand-sorting to remove fine particles. In contrast to the previous stage, the ***ebuk*** tossed from the ***sefi*** (sample 20) contains mainly of light chaff elements with fewer spikelet forks or glume bases attached.

This winnowing action on the ***sefi,*** called ***mentertar,*** is accompanied by ***mubukats,*** a term which refers to the up and down motion of the ***sefi,*** employed to toss materials while sorting or discarding. In ***mentertar*** several fractions are separated quite deftly. It involves shaking the ***sefi*** in a sideways and circular motion, an operation designed to sort materials and remove impurities. Elements are gradually separated into different components on the ***sefi*** and are sequentially tossed or scooped by hand into various containers. Implements resembling the ***sefi*** are used by Tuareg peoples in Ahaggar, where similar winnowing techniques are practiced (Gast and Adrian 1965:23–25, 31; Nicolaisen and Nicolaisen 1997:330). ***Mentertar*** seems comparable to "yandying" practiced by Australian aboriginal women of the Great Sandy Desert, northwestern Australia. Cane (1989:105–106) suggests that this technique is a substitute for winnowing and sieving. It is also similar to "winnowing by shaking" using a ***chaata*** as observed in Andra Pradesh by Reddy (1991:23; 1997:171–172), who also describes it as a replacement for fine sieving and an adaptation to processing smaller-grained cereals. Unlike the examples from Australia and India, ***mentertar*** does not appear to be a blanket replacement for fine sieving, but instead, it is employed in the latter stages of all household cereal processing to remove the last impurities. However, in the case of smaller-grained cereals such as tef and finger millet ***mentertar*** does appear to replace fine sieving, where it is preceded by coarse sieving (in the absence of ***mihehai***). Thus, emmer represents one of two cereal processing pathways observed in central Tigrai: one for larger-grained cereals (all wheats, barley, and sorghum) characterized by the use of ***mihehai*** followed by ***mentertar*** (without coarse sieving); and another for smaller-grained cereals (tef and finger millet) which are subjected to coarse sieving followed by ***mentertar*** (without ***mihehai***) (D'Andrea in prep.).

Gurdie brought from the threshing floor is processed independently. If ***shahan*** wheat or ***burguda*** barley grains are present they are removed by hand, but this is not usually necessary. This is because ***gurdie*** is gathered by raking on the threshing floor, an action that tends to miss loose grains of wheat and barley. ***Gurdie*** is first sieved and winnowed using a ***mihea,*** and this can be accompanied by the simultaneous removal of large straw pieces and stones by hand. Three fractions are produced: 1) ***guchach*** that falls through the sieve and is used as fodder; and remaining on top are 2) ***gulam*** which is tossed off the ***mihea*** and used as fodder for livestock, and 3) ***gurdie*** which remains on top and is collected by hand. It is then hand-sorted with cleanings discarded and stored in the living quarters. When required, stored ***gurdie*** is processed in small amounts in a manner similar to but separate from stored spikelets (Figure 4). Informants process ***gurdie*** separately because it contains more impurities. A comparison of equivalent residues produced during post-pounding processing of semi-clean spikelets versus ***gurdie*** in Table 3 (e.g., compare samples 13 and 27; 14 and 28; 15 and 29; 16 and 30; 17 and 32; 18 and 31), reveals that ***gurdie*** at all processing stages does tend to include more impurities.

In the recent past, grains were ground by hand using a stone saddle quern (***metahan***). Communal mills were introduced in the region in the early 1990s, and are now used by many families for milling grain. Several informants described the current methods employed in flour milling. After grinding at a communal mill,[9] emmer flour is sieved at least twice at home, first using a coarser sieve (***monfit tara***) which produces ***haser nifai*** and ***kitkat***. These by-products are fed to chickens. Flour is sieved a second time, preferably using a finer sieve (***monfit shi'i***), but because this implement is relatively expensive, many women use the coarser sieve once again. Cleanings from this second sieving are normally discarded and rarely used in making ***sua.*** Informants in this region emphasized that emmer is never used in beer making, only finger millet, sorghum, and barley.

Whole emmer grain is consumed after roasting on a metal griddle to produce ***kollo*** or used in making a weaning food known as ***mahoyo*** (or ***tuto***). The ***kollo*** making process is described in detail elsewhere (Lyons and D'Andrea in prep.). Farmers agree that of all available cereals emmer makes the best quality ***kollo*** because the grains are "very tender" and have a "sweeter" taste. To demonstrate this, informants encouraged the authors to taste ***kollo*** made from ***shahan*** wheat and emmer, both of which were roasted on a metal griddle in the traditional manner. It was immediately apparent to us that emmer ***kollo*** is far superior in taste and is less gritty than ***kollo*** made from ***shahan*** wheat. The delicate texture of emmer ***kollo*** may be related to thinner pericarps present in hulled wheats (Le Clerc et al. 1918:216; Nesbitt and Samuel 1996:43). In preparing ***mahoyo,*** whole grain is soaked, boiled, and forced through a fine metal sieve (formerly made of basketry). Processed ***kitkat*** is well suited to this purpose because it consists of already broken grain. The strained mass is boiled and fenugreek (*Trigonella foenum-graecum* L.), honey, and milk are added.

Emmer flour is used in making leavened and unleavened staple breads, mainly ***embasha, kicha,*** and ***taita. Embasha*** made at Easter is traditionally made from emmer flour. When making ***taita,*** emmer flour is never used on its own, but mixed with barley flour at a ratio of 2:1 (barley:emmer) or with sorghum at a ratio of 1:1. The flour also is used to make a soup called ***mouk.*** Emmer flour is considered the best to make ***ga'at*** porridge, which is eaten mainly by invalids, nursing mothers (Edwards 1991:53), sick people, and children, because emmer is considered to be more easily digested than other wheats. Informants generally describe emmer as a cereal with special properties and medicinal value. Others report that broken bones heal more quickly with a diet of emmer porridge (Tesfaye and Getachew 1991:51).

DISCUSSION

The Tigrayan peoples consulted in this study continue to cultivate emmer as part of a living tradition despite the accessibility of naked wheats. Production is at the household level, and as such, the information produced herein is complementary to that provided by Hillman (1984b), who examined larger-scale communal bulk processing in Turkish villages. Moreover, the Tigrayan evidence has revealed aspects relating to household production that are not otherwise preserved in ancient texts (Murray 2000; Samuel 1993) or as archaeobotanical remains (Hillman 1984a; Jones 1981), and are not directly measurable in controlled experiments (Meurers-Balke and Lüning 1999; Samuel 1993). In particular, it draws attention to a largely overlooked aspect of women's lives in rural communities, namely, the burdensome task of dehusking and subsequent cleaning of hulled or intercropped cereals once they are brought to the household from the threshing floor. As such, it is clear that the bulk of labor necessary in non-mechanized post-harvest processing of emmer rests with women.

In the household setting, emmer is considered among the most labor-intensive cereals to process, and this is often cited as a reason for the gradual disappearance of this crop. One is immediately impressed by the high degree of skill exhibited by women who are able to separate as many as four different elements using a ***mihea*** simultaneously as a sieve and winnowing tray. These processing techniques, and the time women spend in grain cleaning activities have been passed over in agronomic and ethnographic research (for exceptions, see Cane 1989; Gast and Adrian 1965; Tewolde 1993), even in investigations that purport to examine traditional methods (e.g., Asiedu 1989; Bencini 1991; Redhead 1989). These latter studies are more explicitly concerned with storage and milling performance of cereals for the purpose of improvement. Often, these descriptions end with threshing and the sequence is picked up again with food preparation with mention made of milling or general cleaning, ignoring the complexity and time consuming nature of these activities (e.g., Holm 1956:12).

It has been demonstrated that the recent introduction of the communal mill has resulted in a marked improvement of women's lives in rural Ethiopia (Tewolde 1993:224–225). However, the separation of grain from hulls, necessary in processing emmer, hulled barley, sorghum, and finger millet, continues to claim a substantial amount of time. The onerous nature of these tasks is further compounded by the operations necessary in hand-separating intercropped grains. When one considers the additional burden of grinding grain into flour, as well as other household tasks such as fetching water and fuel, it has been suggested that rural Ethiopian women had barely enough time to sleep (Tewolde 1993:222–232). Tigrayan informants report that hand-sorting and grinding on a saddle quern took up as many as 10–12 hours per day on alternate days. With the introduction of the communal mill, processing and hand-sorting of intercropped cereals now occupy an estimated 4–5 hours on alternate days. Women have dealt with these obligations by relying on shared labor groups, termed "Mutual Support Networks" (MSNs). These organizations are based on family ties or residential proximity and are means by which women help each other in times of high workload, including life-cycle celebrations and bulk food processing (Dessalegn 1991:31–38). Support networks are developed to varying degrees in different parts of Ethiopia, although milling and hand-sorting of intercropped cereals now have a rather diminished role in MSNs in the study area. The introduction of the mill has made it possible for women to participate in Food-for-Work programs during seasons of failed harvests. It has also allowed them time to make baskets and other handicrafts for sale in local markets, a pursuit which has contributed to the transition of Tigrayan villagers to a modern cash-based economy. Interestingly, since the introduction of communal mills, the overseeing of flour milling has shifted from the domain of women to that of men (Tewolde 1993:232).

Many of the elder Tigrayan women we interviewed are of two minds concerning the discontinuation of labor-intensive activities such as emmer processing and milling flour on the saddle quern. They certainly do not miss the hard work, but they do lament the loss of socializing that is an important aspect of these work support groups. As such, the introduction of communal mills by the Tigrayan government is beginning to set in motion a social impact illustrative of the trend of individualization where actions and decision making by individuals gradually become independent of community ties, resulting in increased autonomy of households (Counihan 1999:35). This phenomenon has been examined specifically in a context of bread making in an anthropological study carried out in Sardinia. In this region, villages scattered in a rugged mountainous landscape remained isolated from early twentieth-century economic developments taking place elsewhere in Italy. Traditionally, bread was considered the most significant food in Sardinian cuisine and women assisted each other in the long process of baking in the home. These activities brought family, friends, and neighbors together during which they gossiped about their lives and village issues, thereby reaffirming local cultural norms. Following the First World War, bread baking in the home steadily declined and ultimately disappeared for various reasons, including the establishment of public bakeries, closure of grain mills, and introduction of mass-produced breads. The use of public bakeries was initially resisted, but eventually bread baking and other home-based food processing activities ceased, along with the concomitant social interaction. In a manner analogous to communal mills in Tigrai, bread baking in Sardinia has shifted from the purview of women to that of men who operate the bakeries, and in so doing, social relations in the community are irreversibly transformed (Counihan 1999:32–35).

Despite the shared labor practices observed in the field and recounted by informants, most households in the study area possess a complete set of equipment to produce breads and all other foods, including grinding stones, ovens, and mortars (D'Andrea et al. 1999:114–116), or at least they did so in the recent past (for a contrasting archaeological example, see Samuel 1999:133–141). Apart from times of food shortages, rural households typically aim to meet all food consumption requirements with few culinary items purchased from regional markets (Tewolde 1993:190). Unfortunately, there are no archaeological investigations available on rural domestic architecture in Ethiopia, although it is clear that emmer has been cultivated there since pre-Aksumite times (Boardman 1999:143; Phillipson 2000:469), and reached such prominence as to be illustrated on Aksumite coinage (Phillipson 1993:354–355). Given the Tigrayan ethnoarchaeological data on labor requirements in the household processing of intercropped and hulled cereals such as emmer, we may speculate that in the absence of state-supplied rations or food exchange networks, shared female labor in cereal processing must have been a fundamental necessity of rural life, certainly in recent times, and perhaps in the more distant past. Studies of Aksumite and later inscriptions indicate that in addition to meeting normal family food consumption requirements, rural peoples were obliged to supply goods to kings and local officials in the form of tribute or tax. In Aksumite times, this payment was a condition of land tenure among conquered populations. A remnant of this practice persisted into the Middle Ages and recent times in the form of ***dergo***. Rural inhabitants were obliged to offer ***dergo*** to the monarch, troops, and ambassadors travelling through subjugated lands, as well as to local officials. It consisted of prepared food, such as ***taita***, wheaten bread, flour, oil, sauces, drinks, small game and other comestibles, and occasionally clothing, currency and pack animals. In some cases, the demand for goods could be very great, particularly when required by military expeditions (Kobishchanov 1979:161–166). Providing tribute in the form of bread and flour, as opposed to grain, would have had a significant impact on the workload of rural women, in which case communal labor networks would have been critical.

In marked contrast to household processing, emmer is widely considered among the least demanding cereals to thresh, as normally only one threshing is required to adequately break down a harvest into spikelets. The field threshing of emmer described here differs in some respects from that reported by Hillman (1984b) and from studies of ancient Egyptian reliefs (Murray 2000:524–526). These latter investigations have documented the occurrence of coarse sieving on the threshing floor, where the sieve retains impurities, allowing grains and weed seeds to pass through for further processing (Jones 1984:45). As stated earlier, Tigrayan informants insist that emmer is never sieved in this manner during threshing and coarse sieving is only performed during the processing of tef and finger millet (D'Andrea in prep.). Hand-winnowing on the threshing floor (Figure 8) has no apparent analogue in the available literature on glume wheat processing. In Tigrai it is consistently used as a replacement for the winnowing shovel. It clearly represents a technique used in processing small quantities of all cereals, and as such, may not be expected to occur in communal processing (Hillman 1984b) or be described in ancient sources (Murray 2000). Another interesting feature of threshing in Tigrai is the ubiquitous use of the ***mihea*** in basket-winnowing (Figure 9). While baskets or sieves have been mentioned as alternative winnowing tools employed on threshing floors in Turkey (Hillman 1984b:124) and in ancient Egypt (Murray 2000:525), the ***mihea*** is regularly used in Tigrai as the last winnowing implement in the field processing of all cereals, regardless of grain size. A comparable method has been observed in rural regions of southern India near Madurai, where a funnel-shaped container with no apertures is used after threshing (Richard Shutler Jr., personal communication, 2001). A similar basket-winnowing technique, referred to as "wind-winnowing," is documented in Andra Pradesh by Reddy (1991:23, 25, 1997:170). The Tuareg also employ a basket-winnowing technique in processing cereals on the threshing floor (Nicolaisen and Nicolaisen 1997:274). One could speculate that these basket-winnowing techniques reflect an adaptation to processing millets and similar smaller-seeded cereals, in much the same way as ***mentertar*** is well suited to the household processing of tef and finger millet. Unlike the Near East and Europe, the cultivation of millets and small-grained cereals are major components of agricultural systems in tropical regions of Africa and South Asia. In many ways, Tigrayan practice appears to represent an amalgamation of Near Eastern and tropical African/ South Asian crop processing traditions (D'Andrea in prep.).

Although small sample sizes preclude the possibility of quantitatively characterizing processing residues, several patterns observed at different stages suggest that such approaches may be possible in future studies. Comments on residue composition have been made in previous sections, and these could be tested with larger and more consistent sample sizes. In addition, informants clearly differentiate fodder types, and local terminology used in all cases is consistent, including ***ebuk*** (mainly empty glumes with heavy chaff elements) which is fed to chickens, ***guchach*** (mostly grains of barley and *Avena sterilis*) for donkeys and other livestock, and ***gulam*** (a mixture of several impurities with no dominants) fed to livestock. The storage of these fodders has some potential to be visible archaeologically. These elements along with ***gurdie*** and spikelets from the threshing floor are stored inside main residential buildings while straw from the threshing floor is kept in a fenced courtyard adjacent to buildings (D'Andrea et al. 1999:114–115). Fodders are not normally subjected to processing in addition to that described above, except for extra hand-sorting to remove grains of *Lolium temulentum* L. (***kurdad***). Farmers indicated that these seeds are toxic and produce hallucinogenic effects if grazed by cattle or if ground into flour and consumed by humans in breads. This effect is produced by a fungal infestation (ergot), common in seeds of *L. temulentum,* which has a narcotic effect on humans and livestock (Phillips 1995:18).

Our fieldwork has addressed several questions relating to processing technology and storage of emmer in households, information which has relevance to archaeobotanical interpretations of ancient processing. Emmer dehusking methods have been a major concern of archaeobotanists and agricultural historians, where the role of stone querns versus wooden mortars is at issue. Although dehusking can be accomplished by rotary querns (Beranová 1989:322–323; Nesbitt et al. 1996:236), this technology, which developed in Roman times (Moritz 1979: 9), does not seem to have diffused to Ethiopia. Classical sources such as Pliny indicate that wooden mortars are the instrument of choice in emmer dehusking because they are less damaging to the grain (Pliny xviii, 112; Moritz 1979:22–28). Meurers-Balke and Lüning (1999:244) conclude that although stone saddle querns can be used to dehusk emmer, especially if spikelets are heated to low temperatures, the number of cracked grains produced is exceedingly high. They also find that wooden mortars, in particular a solid mortar made out of a tree trunk (identical to the ***mogu***), is a more effective instrument of pounding (Meurers-Balke and Lüning 1999:241–249). Similar conclusions have been reached by other workers (Harlan 1967:199; Hillman 1984b:130). Vavilov (1931:8–9, Figures 2 and 3) maintains that the normal way of dehusking emmer in Ethiopia is through the use of a tall wooden mortar and a wooden pestle, while grinding grain into flour is accomplished using a stone quern. Such observations are consistent with our ethnoarchaeological study. According to informants, grinding stones are never used to dehusk emmer, because they cause excessive damage to grains. Dehusking invariably occurs in a wooden mortar where the hand-held implement is either metal or wood. In Tigrai, grinding stones are used mainly in milling flour and to remove hulls in grass pea (*Lathyrus sativus* L.) processing (Butler et al. 1999: 129). Distinctly smaller grinding stones are used to pulverize various spices used as flavorings.

Pre-treatment of emmer prior to pounding by parching/drying (Nesbitt and Samuel 1996:46) or wetting also has been widely discussed, both of which are described by Pliny (xvii, 7–8, 97–98). Another Classical writer, Varro (1.63), mentions the parching of spikelets. Parching prior to pounding has been described for rural Turkey (Hillman 1984b:129). Nesbitt and Samuel (1996:43–46) point out, however, that heating may have had other purposes, such as drying an unripe harvest. Meurers-Balke and Lüning (1999:252) conclude that parching is unnecessary in dehusking emmer while Harlan (1967:199) finds that roasting does not appreciably improve pounding: comparable results are achieved by pounding unheated spikelets for a longer period of time. These latter observations are echoed by Adi Hana and Mai Kayeh informants. In this region, parching is never used, but spikelets are dried in the sun for as long as two days prior to pounding. Sun drying is believed to make pounding more effective. In contrast to experiments where moistened spikelets are pounded effectively in shallow mortars (Hillman 1984b:135–136; Nesbitt and Samuel 1996:52; Samuel 1993:280, 2000:560), water does not appear to be necessary when tall wooden mortars are used (Harlan 1967:199; Nesbitt and Samuel 1996:53). Adi Hana and Mai Kayeh informants maintain that spikelets are never moistened when pounded in a wooden mortar. This has resulted in a sequence of processing steps that differ from the processing model developed by Samuel (2000:541) based on several lines of evidence from ancient Egypt. In the Egyptian model, the wetting of spikelets requires a post-pounding drying stage, while drying in Tigrai precedes pounding.

Glume wheat storage practices have been of interest to archaeobotanists. Hillman (1984a, 1984b) suggests that storage in more arid regions of Turkey would have been in grain form, while storage as spikelets was characteristic of areas experiencing wet summers. Although not directly observed by Hillman (1984a: 9), he suggests that in small farmsteads where large processing equipment is not available, storage in spikelet form would be expected to occur. This latter method was commonly used in ancient Egypt (Nesbitt and Samuel 1996:51–52; Samuel 1993:278). The conclusion that glume wheats are best stored as spikelets is supported by several workers (Meurers-Balke and Lüning 1999:241; Murray 2000:527–528) and by Classical writers (Varro 1.63, 1.69). In Adi Hana and May Kayeh emmer storage is always in spikelet form and additional processing is completed in small quantities as required. An exception is when relatively larger quantities are dehusked in preparation for selling at local markets. In this case bulk storage is in grain form (cf. Hillman 1984b:126). Meurers-Balke and Lüning (1999:250) state that as long as stored glume wheats are dried before storage, another drying period immediately before dehusking is not necessary. This may be the case, however, Mai Kayeh and Adi Hana informants always sun dry spikelets before dehusking. The idea that smaller mortars are used in cases when spikelets are stored in households and processed as needed while much larger mortars are used in bulk processing (Hillman 1984b:130) finds support in this study, as ***mogu*** internal diameters average around 20 cm. In a manner analogous to grinding stones (mentioned above), even smaller wooden mortars are used in the study area for processing spices.

The issue of flour sieving is discussed by Samuel (1993:281–282), who concludes through experimentation that emmer flour produced on a saddle quern is sufficiently fine as to not require sieving, despite the fact that this activity is depicted in Egyptian reliefs. Although Tigrayan informants report that communal mills have introduced more impurities to all flours thereby creating the need for several sievings, they unanimously agree that all flours except tef[10] must be sieved even when milled by stone querns. They do recognize, however, that emmer produces fewer impurities when milled on a saddle quern A similar observation is made by Le Clerc et al. (1918:216) who, based on milling experiments, conclude that emmer and Polish wheat (both tetraploids) produce significantly smaller quantities of bran when milled.

CONCLUSION

Although Ethiopia is well known as a remarkable reservoir of agrobiodiversity, genetic resources have been eroding because of civil unrest, poverty, land shortages, environmental degradation, and the replacement of indigenous land races with introduced cultivars (Edwards 1991; Engels and Hawkes 1991; Melaku 1991). The decline in emmer cultivation is clearly part of this overall pattern. Despite these regrettable circumstances and the high processing costs for women in the household, emmer cultivation has persisted in Tigrai, apparently because foods produced from this cereal are highly appreciated. This ethnoarchaeological study of household emmer processing has revealed several technological and social aspects relating to this disappearing crop. It has outlined field winnowing practices that differ from those observed in the Near East and Europe, which may indicate a tropical African and/or South Asian influence in agricultural technology. Several conclusions relating to emmer processing based on experimental replications (Meurers-Balke and Lüning 1999; Samuel 1993) find general agreement in this study, in particular, dehusking, storage, and other processing issues, all of which are relevant to the interpretation of the archaeobotanical record. Finally, although the working conditions of women in Tigrai have certainly improved with the introduction of communal mills, the onerous tasks of pounding, cleaning, and separating intercropped and hulled cereals remain a reality of life. As a result, rural support networks in existence before the establishment of communal mills, although somewhat diminished, still operate with some regularity today. Given the constraints imposed by the nature of these cereals, it is possible that shared female labor in cereal processing was a widespread phenomenon of Tigrayan village life in the recent past, and in all probability, in ancient times as well.

NOTES

[1] The terms "hulled" or "glume wheat" include several species and ploidy levels of *Triticum* such as emmer, einkorn (*Triticum monococcum* L.) and spelt (*T. aestivum* ssp. *spelta* (L.) Thell.). The ears of these wheats break down into spikelets after threshing, and additional processing involving pounding is required to release grain from enclosing hulls. The ears of "naked" or "free-threshing wheats," such as durum (*T. turgidum* conv. *durum* (Desf.) MacKey) and bread wheat (*T. aestivum* ssp. *vulgare* (Vill) MacKey), have grains that are released during threshing and do not require pounding (Zohary and Hopf 2000:33–53).

[2] Spikelets are segments of ears made up of grain that is tightly surrounded by light (glumes) and heavy (spikelet forks, glume bases, rachis segments) chaff components (see Charles (1984) for a description). Emmer spikelets are typically two-grained, but single- and triple-grained forms are also known to occur (Percival 1921:191).

[3] Tigrinya names are included where available. However, there is considerable variation in English transliteration of Tigrinya terms, and those presented here are close approximations.

[4] All informants named in this study have given permission to be so identified.

[5] Tetraploid wheats (genomic designation AABB or AAGG) have a chromosome number of $2n = 28$, and include hulled forms such as emmer, and free-threshing types such as durum and Polish wheat (*T. turgidum* conv. *polonicum* (L.) MacKey) (Zohary and Hopf 2000:28).

[6] Hexaploid wheats (AABBDD) have a chromosome complement of $2n = 42$, and include free-threshing types such as bread wheat and hulled forms such as spelt (Zohary and Hopf 2000:28).

[7] In Tables 2 and 3, "wheat" refers to bread wheat, and remains of crops are listed as common names. Crops not mentioned in the text are lentil (*Lens culinaris* Medik.), chickpea (*Cicer arietinum* L.), and flax (*Linum usitatissimum* L.). These and other crop contaminants were introduced in the field or on the threshing floor.

[8] Hand-sorting refers to removal of impurities, while hand-separation implies the separation of products, especially of grains in mixed harvests.

[9] The following information on food preparation was described by informants and not directly observed.

[10] Although sieving tef flour that has been milled on a saddle quern is considered unnecessary, Tigrayan informants recall that they used to sieve it regardless, to be certain that all impurities are removed.

ACKNOWLEDGMENTS

Our principal consultants in this research are the farmers of Adi Hana, Mai Kayeh, and Adi Ainawalid, who kindly gave their time and energy to teach us about emmer. For this we are very grateful. Wayzaro Yalemser Asbaha and Wayzaro Tadelu Tesfaye deserve special mention for their generosity in sharing their knowledge and experience with us. We thank the Ethiopian Authority for Research and Conservation of Cultural Heritage (Addis Ababa) and the Tigrai Bureau of Culture and Tourism (Mekelle) for granting permission to carry out the fieldwork. This project was funded by a Social Sciences and Humanities Research Council of Canada Standard Research Grant to ACD (No. 410-96-1520). Our principal interpreter was Ato Zelealem Tesfaye (Mekelle Agricultural Research Centre), who also was invaluable as a first-rate field assistant. Field support was provided by Mekelle University staff, as well as Dr. Ann Butler (University College London), Wayzaro Debritu Beyene (Biodiversity Institute, Addis Ababa), Ato Workayehu Amare (National Herbarium, University of Addis Ababa), and Ms. Sheila Boardman (University of Sheffield). Illustrations were designed and drawn by Ms. Shannon Wood (Simon Fraser University). We benefited from the advice of Dr. Tewolde Berhan Gebre Egziabher (University of Addis Ababa), Ms. Sue Edwards and Dr. Sebsebe Demissiew (National Herbarium, University of Addis Ababa), and Dr. Abebe Demissie (Biodiversity Institute). We are especially grateful to Mr. Gerry D'Andrea for assistance with Italian translations, Dr. Ilia Tomski (University of Toronto) for Russian translations, and Ms. Karine Taché (Simon Fraser University) for writing the French abstract. We thank Dr. Laura Morrison (Oregon State University) for informative discussions on variability in emmer and assistance with identifications. Dr. Richard Shutler Jr. (Simon Fraser University) kindly provided information and photographs of millet threshing/winnowing in southern India. Laboratory assistance on processing residues was provided by Ms. Angela Ryan and Ms. Marie-Ange Fall (Simon Fraser University). We are grateful to Dr. Mike DiBlasi and Dr. Kathryn Bard (Boston University), Dr. Naomi F. Miller (University of Pennsylvania Museum), Dr. Wilma Wetterstrom (Botanical Museum, Harvard University), Dr. L.A. Pavlish (University of Toronto), Dr. Diane Lyons (Simon Fraser University) and one anonymous reviewer for critical reading of this manuscript.

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Journal of Ethnobiology 22(2): 219–246 Winter 2002

USE AND SIGNIFICANCE OF PALMS (ARECACEAE) AMONG THE YANOMAMÏ IN SOUTHERN VENEZUELA

JÜRG GERTSCH,[a] FRED W. STAUFFER,[b] ANA NARVÁEZ[c] and OTTO STICHER[a]

[a] *Swiss Federal Institute of Technology Zurich, Institute of Pharmaceutical Sciences, Winterthurerstrasse 190, 8057 Zürich, Switzerland*

[b] *University of Zurich, Institute of Systematic Botany, Zollikerstrasse 107, 8008 Zürich, Switzerland*

[c] *Fundación Instituto Botánico de Venezuela, Apartado 2156, Caracas 1010-A, Venezuela*

ABSTRACT.—Palms play an important role in the subsistence activities and material culture of virtually all indigenous societies in the Amazon. They are widely distributed throughout the forests of southernmost Venezuela, where they are represented by over 60 species from 21 different genera. The present work focuses on the importance of palms among the Yanomamï Amerindians of the upper Orinoco region. The material presented in this article is derived from ethnobotanical fieldwork in several Yanomamï villages between 1997 and 2002, as well as from a complete revision of the relevant ethnographic and ethnobotanical literature. It is our aim to present a comprehensive account of the recognition, ethnotaxonomy, use, as well as economic and symbolic importance of palms among the southern Yanomamï groups in Venezuela, giving also some reference to comparable data obtained from Yanomamï groups in Brazil. Furthermore, observed differences in the use of palms because of acculturation and the resulting changing cultural context are described and discussed. The indigenous names and the economic significance of 37 palm species from 16 different genera are presented.

Key words: Yanomami, palms, Arecaceae, Venezuela, Amazonas, ethnobotany.

RESUMEN.—Es bien conocido que las palmas juegan un importante papel en las actividades de subsistencia y en la cultura material de una gran cantidad de sociedades indígenas en la región amazonica. Las palmas se tienen una amplia distribución en los bosques del extremo sur de Venezuela, donde están representadas por más de 60 especies, agrupadas en 21 géneros. El presente trabajo se centra en la importancia de las palmas entre los Yanomamï de la región del Alto Orinoco. El material expuesto en este artículo se deriva del trabajo etnobotánico realizado en diferentes poblados Yanomamï entre 1997 y 1999, así como de una completa revisión de la bibliografía etnográfica y etnobotánica más relevante. Nuestro objectivo es presentar un informe global sobre el reconocimiento, etnotaxonomía y uso, así como la importancia económica y simbólica de las palmas entre los Yanomamï en Venezuela, incluyendo algunas referencias a datos comparables procedentes de la información ya recabada entre grupos Yanomamï del Brasil. Además, se describen y discuten diferencias observadas en cuanto al uso de las palmas, debidas a la aculturación y sus consecuentes cambios. Se presentan los nombres étnicos y la importancia económica de 37 especies de palmas, agrupadas en 16 géneros.

RÉSUMÉ.—Les palmiers jouent un rôle important dans la subsistance et la culture matérielle de pratiquement toutes les populations indigènes de l'Amazonie. On en trouve beaucoup dans toutes les forêts du sud du Venezuela où ils comptent plus de 60 espèces et de 21 genres. Cette étude examine l'importance des palmiers chez les indiens Yanomamì, amérindiens de la région du Haut Orénoque. Nos informations viennent de deux sources: les donées recueillies lors d'activités ethnobotaniques sur le terrain effectuées entres 1997 et 2002 dans plusieurs villages yanomami, et une revue exhaustive de la littérature ethnobotanique et ethnographique pertinente. Notre but est d'offrir un compt rendu détaillé de la perception, ethnotaxonomie, et de l'exploitation des palmiers par les groupes yanomami du sud du Venezuela. Nous expliquons également leur importance symbolique et économique et nous faisons quelques références aux données comparables recueillies parmi les groupes yanomami du Brésil. De plus, cet article décrit les différentes utilisations de palmiers qui résultent de l'acculturation et la modification du contexte culturel qui s'ensuit. Pour terminer, nous expliquons l'importance économique de 37 espèces de palmiers (16 differents genres), et nous listons leurs noms indigènes.

INTRODUCTION

Palms are an important economic resource in the Estado Amazonas (Amazon State) of Venezuela (see Guánchez and Romero 1998; Narváez and Stauffer 1999; Narváez et al. 2000). The Arecaceae remain among the most significant plant families with respect to cultural importance and economic value among all ethnic groups of the Amazon (Balick and Beck 1990; Kahn and de Granville 1992). This is also true for the Yanomamï communities in Venezuela. Despite numerous publications about this ethnic group, a comprehensive ethnobotanical study about the use and significance of palms among the Yanomamï is lacking. Contrary to earlier observations (Anderson 1978), the Yanomamï in Venezuela use palms extensively; the use of palms also appears to be more important than that of other plant families. Palms have entered almost every aspect of life among the Yanomamï, from subsistence to material culture, medicines, and rituals.

Early ethnographic investigations among the Yanomamï, such as those by Vinci (1961), Zerries and Schuster (1964, 1974), Polykrates (1967), Knobloch (1970), Montgomery (1970), Cocco (1973), and Anderson (1978) provided the first vernacular names of palms in the Yanomamï language. Between 1954 and 1955, Zerries and Schuster carried out the first comprehensive ethnographic work among the Yanomamï in Venezuela and published several names and uses of palms (Zerries and Schuster 1974), but no botanical specimens were collected. This initial study was followed by a series of detailed ethnographic descriptions about different linguistic subgroups by Polykrates (1967), Chagnon (1968, 1992), Lizot (1972, 1980), Becher (1974), and Peters (1998). Anderson (1978) published the names and uses of twenty palm species among a particular Yanomamï community, the Xirianateri (Shirianatheri) of the Toototobi area in Brazil and he collected botanical specimens for each palm mentioned. Today, Anderson's study about palms still represents the most complete study from the Brazilian side. Fuentes (1980) provided new ethnobotanical data about the Yanomamï of the Ocamo region in Venezuela, including information about 16 palm species. More recently, Milliken and Albert (1999) published their comprehensive ethnobotanical work derived from two Yanomamï communities of the Demini region in Brazil, including botanical and ethnographic information for about 17 palm species. At present, a detailed comparative study about palms among the Yanomamï is lacking.

During the first author's visits to the Yanomamï villages around Ocamo, Platanal, as well as Hasupïwei, Irokai and Mokaritha in the Sierra Unturán, it became evident that palms are a significant economic and cultural resource. We were therefore prompted to study the significance of palms from a comparative point of view. In this paper we present new information about the ethnotaxonomy and use of palms in Yanomamï culture.

METHODOLOGY

Most of the information for this study was collected during two longer periods of fieldwork by the first author in July–October 1998 and January–February 1999. During that time six Yanomamï villages were visited: Ocamo, Aratha, Mahekotho, Hasupïwei, Irokai, and Mokaritha. All of the communities belong to the linguistic subgroup Yanomamï. Field observations also were incorporated from other shorter visits by the first author to several other villages along the Mavaca and Siapa in 1992 and Ocamo and Orinoco in 1997 and 1999. The content of this article was finally discussed again in the villages Shotemi, Hokotopïwei, Hasupïwei and Ashitowë in January–March 2002. Informal and open structured interviews were conducted in the communities Hasupïwei, Irokai and Mokaritha. Determinations of the palms were made in situ by two informants. Palm material was further taken to the village and consensus on the information given by our main informants was agreed upon by at least four male and two female representatives of the community. Plant material always consisted of leaf material and the infructescence. Use reports were gathered in the villages. Unclear use reports were not considered for this study. Data obtained during trekking was corroborated by at least three informants. Collections and pictures of the most useful palms were made in the Sierra Unturán and lower Sierra Parima. Voucher specimens were prepared as described previously (Stauffer 2000) and deposited at VEN and partly also at MYF. The second author further collected botanical specimens as well as ethnobotanical information in the Mavaca area in 1999 and also revised collections at the VEN, NY, US, MYF, TVAF, PORT, MER, GUYN and CAR herbaria[1] (Stauffer 2000).

The artificial scale of importance used for this study (see Table 1) is based on the use reports collected in the different villages. Each use report contains information about the specific use of a palm species, including information about the frequency of use. The scale is based on 218 use report entries.

THE YANOMAMÏ IN VENEZUELA

The Amazonas State in Venezuela occupies over 180,000 km^2 (Figure 1). Almost 90% of its total area is occupied by rain forests and about 45% of it is protected by the Venezuelan government as National Parks and Monuments or as upper Orinoco-Casiquiare Biosphere Reserve (Huber 1995). The territory inhabited by indigenous people is further protected by law through the *Dirección de*

FIGURE 1.—Area of fieldwork. The villages where the ethnobotanical study took place: 1) Aratha; 2) Ocamo; 3) Platanal (Mahekoto); 4) Hasupïwei; 5) Irokai; 6) Mokaritha; 7) Hokotopïwei; 8) Shotemi; 9) Ashitowë. Hatched area shows where most of the palms were recorded.

Asuntos Indígenas (D.A.I). The total population of Amazonas State exceeds 100,000 inhabitants, 50% of whom are local Amerindians (*indígenas*). The Amerindians belong to thirteen ethnic groups, the biggest of which is represented by the Yanomami (also Yanomamo, Waika, Guaharibo or Shiriana). Of a total indigenous population estimated at around 17,000 people, the Venezuelan Yanomami at present number about 11,000 (Gertsch 2002). The ethnic group Yanomami is currently subdivided into four linguistic groups (Migliazza 1972): the Sanïma, the Nïnam, the Yanomam, and the central Yanomamï. The Sanïma live to the north of Brazil, in the upper Auaris and Erebata region as well as in the Estado Bolívar in Venezuela; the Nïnam live in the upper Paragua region, north to the Sierra Parima and around the Apiau and Mucajai rivers; the Yanomam live in the watershed of the Catrimani and Demini rivers, as well as in the Venezuelan-Brazilian Sierra Parima. The Yanomamï, which is the group investigated here, inhabit the upper Orinoco and its tributaries Ocamo, Mavaca, and Siapa, the western communities of the lower Sierra Parima and the southern communities in the Sierra Unturán and Sierra Tapirapecó being the most isolated. It is generally accepted that the ethnic epicenter is the Sierra Parima from where migration might have started (Smole 1976). For simplicity we here always refer to the ethnic description when using the term Yanomamï, if not otherwise stated.

Settlement.—The Yanomamï live in communities of 20 to 200 individuals in provisional shelters (***yahi***) or circular communal houses (***shapono*** or ***yano***). Each roundhouse has an open space in the middle, which represents a common area where community affairs are discussed and feasts are held (Figure 2). The actual living area is thatched with palm leaves and is situated on the outside of the roundhouse with just one fence-like wall at the back. The ***shapono*** is divided into sections, each representing a social nucleus, usually a family or a clan. Location and size of a Yanomamï community strongly depends on economic alliances with other communities. There are many examples where communities split up because of political conflicts or even warfare between clans or families (Chagnon 1997; Ferguson 1995). Probably more than half of the approximately 110 communities in Venezuela are still semi-nomadic and move their village every three to seven years. The groups then move between 5 and 80 km further on (Lizot 1971) and so create a new territory. This migration activity is an important custom in the sustainable use of the resources. Generally between February and April and between August and October the Yanomamï community goes for long treks (***wayumi***), and it is common to find that whole villages are abandoned for two or three months.

Subsistence.—The Yanomamï are not only hunters and gatherers, but also shifting cultivators (Lizot 1978). About 60% of their food originates from cultivated plants. Each settlement has one or more garden areas (***hikari***) outside the ***shapono***. The garden is split up into sections, each area being kept by a different family or clan. Shifting cultivation is a key factor in subsistence activities, which are segmented into gender specific roles. Among the most important crops are *Musa paradisiaca* L. (***kurata*** and ***tate***), *Bactris gasipaes* Kunth (***rasha kë si***), *Nicotiana tabacum* L. (***pêê nahe***), *Xanthosoma* spp. (e.g., ***ohina***), *Manihot esculenta* Crantz., and *Zea mays* L. (***yono***). In addition to the wild palm fruits, the Yanomamï collect other edible wild plant products, such as the fruits of *Clathrotropis* spp. (***wapu kohi***), *Bertholletia excelsa* Humb.& Bonpl. (***hawari kohi***), and *Micrandra* spp. (***momo kehi***). The traditional world of the central and southern Yanomamï is divided up into village (***yahi***), garden (***hikari***) and forests (***urihi***). The use of palms is not restricted to any of these segments.

During the treks the whole community may explore remote areas, which can be over 100 km away from their village. While the men hunt game and collect fruits, honey and small animals, the women collect a variety of wild plant and fungal products and also catch smaller animals, such as river crabs (***oko***) (Pseudothelphusidae and Trichotactylidae), and fish (***yuri***). The consumption of palm

FIGURE 2.—Communal roundhouse with palm-thatched roof (*Geonoma* spp. and *Attalea* spp.) in Hasupïwei.

products is an important tradition for subsistence during the treks. During migration or trekking activities the Yanomamï explore new habitats, which are sometimes distinct ecosystems with different plant species composition.

HOW PALMS ARE CLASSIFIED

The Denominator **Si** *as Generic Label for Palms.*—We could not find a family-specific classification system for the Arecaceae among the Yanomamï communities visited in Venezuela. According to our informants, palms can always be put into the category ***si***. The nominal classifier ***si***, however, designates not just palms, but also other monocots—the Musaceae, Strelitziaceae, as well as members from the Poaceae. In addition, some Cecropiaceae and Mimosaceae are also given the attribute

si. The literal meaning of ***si*** is 'big surface', and it also means skin, bark, and covering. The word ***si*** (***sikï*** or ***sipë*** for plural) stands for a category and is put after the name (e.g., ***waima (kë) si,*** a *Euterpe* species). According to our informants, palms can always be put into the category ***si***. Even though the Yanomamï cannot tell exactly why the nominal classifier ***si*** is added to some plant species and not others, they say that it has to do with leaf form, not size. Thus leaf morphology appears to be the main criterion for the class ***si***. We conclude that especially plants with overall palm-like leaf arrangement (e.g., *Gynerium sagittatum* (Aubl.) P. Beauv., *Musa* spp., *Calathea* spp., *Cecropia* spp. and *Phenakospermum guyannense* (L.C. Richard) Endlich. ex Miquel) are put into this category. The more significant palm species, such as *Bactris gasipaes* Kunth and *Attalea maripa* (Aubl.) Mart. are not always accompanied by the nominal classifier when named as one plant. When several palms are referred to, the plural ***sikï*** or ***sipë*** seems to be required; hence, two or more *Bactris gasipaes* palms are called ***rasha sikï*** and their infructescences are called ***këkï***, which stands for a homogenous clustered object made up of individual units. With respect to the Musaceae and related plants, the Yanomamï point out the similarity in leaf morphology with palms. We further assume that the nominal classifier ***si*** describes the way palm leaves grow, out from a central trunk.

Spines as Characteristic Classifiers.—The spiny palms with lesser economic importance are also given the classifier ***mïsi***, which might either be an abbreviation for ***mïsïkï*** (spines) or a fused term derived from ***mïsïkï*** and ***si***, such as ***hoashi mïsi*** (*Bactris bidentula*) and ***mïsïkïri*** (*Desmoncus polyacanthos*).

Leaves as Use-based Classifiers.—Palms whose leaves are used regularly are often given the classifier ***henakï*** (leaves) and would not normally be referred to as ***si***. ***Henakï*** could be seen as a use-based category, with species from different families. Some species of the genus *Geonoma* are called and recognized by their leaves, for example, ***tharai henakï*** (*Geonoma baculifera* (Poit.) Kunth). The Yanomamï would therefore talk about the "***tharai*** leaves" rather then the ***tharai*** palm. The same is true for certain palms that produce edible fruits, such as ***eteweshi*** (*Mauritia flexuosa* L.f.).

Fruits and Hearts as Use-based Classifiers.—Unless specified, Yanomamï colloquial speech does not distinguish palm fruit from the whole plant. There are, however, few exceptions where there are words denoting particular fruits. For example, the endocarp of the fruit of *Mauritia flexuosa* is called ***kõhõmo***. They can provide detailed descriptions of palm fruits (***këki***), especially when a large palm infructescence has been located and is being reported to the others. For example, almost ripe fruits, which can be collected in a few days time are referred to as ***opi këkï***. Palm hearts are generally called ***kupu***.

Some Evidence for a Female Attribute to Palms.—A linguistic variant of some plant labels assigns gender, usually female, to the plant name; the suffix ***-ma*** or ***-na*** indicates female. Several such palm names include ***komishima*** from ***komishi, yawatoama*** from ***yawatoa, pahana*** from ***paha*** and ***konoporima*** from ***konopo***.

PALM LABELS SHARED BY DIFFERENT LINGUISTIC SUBGROUPS

During our ethnobotanical study we found that even very distant Yanomamï communities use the same labels for economically important plants, but used different names for many other plants. Although we cannot provide a glottochronological analysis, cultivated species, certain wild taxa with high cultural significance, and palms more often have a phonetically similar label in the different language subgroups (Sanïma, Nïnam, Yanomam and Yanomamï) that otherwise show significant linguistic variations.

The ***warapa*** tree (Burseraceae), for example, is called ***warapa kohi*** in all language subgroups. The same is true for several palm species, such as *Bactris gasipaes* (***rasha***), *Euterpe oleracea* (***waima***) and *Socratea exorrhiza* (***manaka***). It is interesting to note that the indigenous name ***manaka*** (not to be confused with the Spanish name for *Euterpe* spp.) is also used for *S. exorrhiza* by the neighboring Carib tribes, such as the Mayongong (Henderson 1995).

We calculated the percentage of shared palm names relative to the number of palm species named by two distant Yanomamï groups. Comparative phonetic data from distant villages in Venezuela, such as Aratha of the upper Ocamo and Mokaritha of the Sierra Unturán, showed a high number of shared palm names (>85%) among fifteen palm species. This is quite remarkable because these two communities are separated by over 150 km air distance and they probably have not been in contact with each other for a long time. Comparing phonetic data on palm labels obtained by other investigators, we again found a very high number of shared palm names: 18 out of 19 names were identical with the distant Yanomamï groups south to the Serra da Neblinha region in Brazil (Knobloch 1970; Polykrates 1967). On the other hand, few equal palm names (5 out of 20 names) were found with the Shirianatheri in Brazil, where Anderson carried out his research (Anderson 1978). Comparing the data recently published by Milliken and Albert (1999), we again found little agreement in palm names: only 4 out of 17 names were shared among the ones that were recorded in the Demini region. There are, however, some names that have a common root. For example, the name of the small palm *Iriartella setigera* is ***yoroama si*** among the Venezuelan communities of the South and it is called ***horoma si*** among the adjacent Brazilian communities. Palm names reported by Anderson and Milliken are almost identical (15 out of 17 names), which is not surprising when taking into account the short distance between their study areas. Looking at migration patterns (Chagnon 1997; Valero 1984), it becomes obvious that the distant groups to the south of the Sierra Tapirapecó are related with the Shamatari groups in Venezuela, whereas the communities studied by Anderson and Milliken are probably more related to the eastern Yanomamï groups. The conserved ethnotaxonomy for palms might reveal a common, maybe not too distant origin of certain Yanomamï groups.

The question concerning why there is a certain amount of concordance of plant names between very distant groups is an interesting one. It is not clear how the names for palms originated and what the ages of the different names are. Palms are frequently used among the Yanomamï and they sometimes serve as sources for names given to humans. Once a person dies, the name becomes taboo and cannot be spoken out anymore. There are cases where related objects had to be renamed because of the death of a person bearing its name. There are, however, no real data on that subject related to plant ethnotaxonomy.

PALMS IN MYTHOLOGY, CHANTS, AND RITUALS

Yanomamï mythology is complex and there are many tales; we only present the most important examples related to palms. The socioeconomic importance of *Bactris gasipaes* (***rasha***) among all the Yanomamï groups is shown by the substantial amount of folklore about the origin of this palm. According to a tale told by the Wawanaueteri (Zerries and Schuster 1974), a man called Koimawë was the first owner of the ***rasha*** palm (*B. gasipaes*). He fell in love with the daughter of deer (***haya***) and transformed himself (by making his legs very thin) into a deer, too. The deer people were cultivating the ***manaka*** palm (*Socratea exorrhiza*) and thought they were cultivating ***rasha***. It was Koimawë, who had transformed himself into deer, who tried to convince the deer people to cultivate proper ***rasha*** (Polykrates 1967). Becher (1974) recorded a tale where the evil spirit ***pore*** sent a bird to plant ***rasha*** palms. According to Knobloch (1970), the Yanomamï had a tale that said that it was the cultural hero Omawë who taught the Yanomamï to cultivate ***rasha*** palms. Helena Valero (1984) relates that the Yanomamï she lived with knew a tale about the origin of the ***rasha*** palm. According to them, the bird people celebrated a ***reahu*** feast and also invited a Yanomamï man. When the bird people turned into real birds, the Yanomamï took some of the ***rasha*** seeds with him. These are examples showing that the ancient people (***no patapï***), who later transformed themselves into animals, also ate palm fruits. Zerries and Schuster (1974) even go as far as to see a close relationship between the consumption of ***rasha*** fruits by some women and the overall transformation of people into animals.

The little ghosts called ***amahiri*** are said to live under the earth; apparently they are like tiny Yanomamï from earlier times. When asked about the nutrition of the ***amahiri*** our informants told us that they eat ***rasha***.

Recognition of a palm species is not always straightforward, as shown by a mythological tale which is known among the linguistic groups Yanomamï and Yanomam in southern Venezuela and Brazil, respectively (Wilbert and Simoneau 1990; Zerries and Schuster 1974): The ***hekura*** (spirit) Hayariwë, a deer who was Yanomamï, sent his daughter Hayarioma to collect the tasty yellow ***rasha*** fruits he had seen the other day. When Hayarioma got to the palm she realised that her father had mistaken the fruits because they were ***manaka*** (*Socratea exorrhiza*) fruits, which look similar, but taste more astringent and bitter. Hayarioma explored the forest and finally found real ***rasha*** fruits and brought them back to her father. Hayariwë tasted the fruits, took ***epena*** (a hallucinogenic snuff) and transformed himself into a deer.

Ayakorariwë, the spirit of the bird ***ayakorami***, whose song is "***aya aya koa koa***" is said to be the creator and spiritual owner of ***rasha*** (see also Zerries and Schuster 1974). When the Yanomamï in Mokaritha plant ***rasha*** seeds or sprout cuttings they carry out a ritual whereby they imitate the song of the ***ayakoroami*** bird, whose alter ego or soul (***no uhutipë***) resembles that of the ***rasha*** palm. They believe that the ***rasha*** palms planted by women grow smaller and produce fruits earlier than the palms planted by men. According to Becher (1974), certain groups in Brazil use the wood of *B. gasipaes* to make amulets. These rectangular amulets (***porehëwë***) are handed over to the young men after an initiation ritual by the chief. Because such amulets made of palm wood are not known to most of the Yanomamï, we conclude that they are an unusual feature of the southern Brazilian Yanomamï.

In his work *Poré/Perimbó*, Becher (1974) also writes about a ritual carried out by the women. If a woman's wish for a child does not become true she carves a little penis out of wood, inserts it in her vagina, and later wraps it in a ***rasha*** leaf. This package is then laid down at a ***rasha*** palm together with food sacrifices. Since such rituals are not known to the Yanomamï women in the area of our fieldwork and have not been reported by others, we assume that they might have been adopted from neighboring tribes. To our knowledge, the practice of food sacrifices is not generally known among the Yanomamï.

Many culturally important plants have animal spirits (***hêa***), which have the role of announcing the presence of the plant. These spirits are strongly associated with certain animals, most often little birds (Zerries and Schuster 1974). In Hasupïwei the animal spirit of the ***rasha*** palm is said to be a wasp called ***kopina napë*** whereas the spirit animal of the ***manaka*** palm is the humming bird ***tesho***. The ***paha*** palm has a ***hêa*** called ***toho*** (a little bird).

In addition to the ***hêa*** spirits, the ***hekura*** spirits, which are summoned by the shamans, play a role in palm mythology. The ***hekura katioriwë*** is the creator of the alter ego (or soul of the image) of the ***kareshi*** (*Attalea maripa*) palm. The palm ***hoko*** (*Oenocarpus bacaba*) plays a certain role as material for ornamental purposes (Figure 3). The adornments derived from the ***hoko*** palm might be generally associated with the ***hekura*** spirits because they are also used in the puberty initiation ritual of the girls and the ***hekura*** apparently like ***hoko sikï***. Women often wear fine stripes (***hoko sikï***) made of young ***hoko*** palm leaves in their ears or in a string bound around the arm. Interestingly, ***hoko sikï*** stands for several other kinds of auricular adornments not necessarily made of the ***hoko*** palm. ***Hoko sikï*** is also the name for the palm leaves of *O. bacaba*, which are used by the Yanomamï dancers during the presentations (***praïaï***) before the feasts (Mattei-Muller, personal communication).[2]

Spirits known among the Yanomamï are usually anthropomorphic and sometimes have a kind of crown of light (similar to our halo). During the chanting (***hekuramou***) of a shaman (***shapori***) in a village of the lower Siapa in 1992, the first author observed that a ceremonial crown (***wathoshe***) made of *Leopoldinia piassaba* fibers was worn, which the shaman associated with luminous radiance. The songs (***amoa***) that are occasionally sung by the women during food collection, harvesting or hunting feasts are often associated with palms. Song topics include "the leaf of the ***manaka*** palm is big" and "how beautiful are the young leaves of the ***hoko*** palm." Also the men sing songs about palms, often related to mythological topics, for example, about the leaves of the ***hoko*** palm and how they turned into mountains.

Palms are also employed in sorcery. There is a magical *Cyperus* species called ***manaka këkï***, which appears to be associated with the palm ***manaka kë si*** (*Socratea exorrhiza*). ***Manaka këkï*** is employed by men to harm women by making

FIGURE 3.—Yanomamï woman with ear ornaments (***hoko sikï***) made of fresh leaflets of *Oenocarpus bacaba.*

them sterile, weak, and very thin (***manakapë***). This sorcery might eventually kill the women. The bulbous root of ***manaka këkï*** is mixed with little wooden pieces of the palms ***manaka*** (*S. exorrhiza*) or ***tharai*** (*Geonoma deversa*) and placed over the sleeping women. The mixture can also be added to a woman's food. Since the ***manaka*** palm is associated with the origin of women and fertility (Zerries and Schuster 1974) it is possible that there is a relationship between the black magic ***manaka*** and the ***manaka*** palm. Some men in Hasupïwei and Mokaritha claim that the ***manaka u***, the sap of the palm, can cause the death of a woman when used in sorcery.

According to Yanomamï mythology, Omawë, the great mythological ancestor, once prepared a poisonous arrow point. He cut splinters from the ***yoroama*** palm (*Iriartella setigera*) wood and spread curare over it. When he laid the arrow point across the path it turned into a poisonous ant (Wilbert and Simoneau 1990). The ***yoroama*** palm appears to be associated with the origin of poisons in general and arrow poisons in particular (see section about *Iriartella*).

PALMS AS ANTHROPONYMS AND THEIR ROLE IN THE NAMING OF VILLAGES AND GEOGRAPHIC FEATURES

The Yanomamï express ideas about their environment within their language in many ways; for example, the names of plants and animals are frequently associated with each other and with their geomorphological environment. Human names among the Yanomamï are treated differently because they need to be kept secret and not spoken out in presence of the person. We assume that this name taboo is associated with a threat of incest because it obliges the inhabitants of a village to call each other by their grade of relation or by a nickname.

The real names are often derived from plants, and frequently from palms. A few examples of man's names derived from palms are: Rashawë (*Bactris gasipaes*), Yeisiwë (*Oenocarpus* sp.), and Hayakawë (*Euterpe* sp.). Among the women the following names were found: Taraiyoma (*Geonoma* sp.), Rashayoma (*Bactris gasipaes*), Waima (*Euterpe* sp.) and Hokosikïyoma (*Oenocarpus bacaba*). A child's name, which is usually given in the third year, may be associated with the place where his or her placenta was hidden after its birth.[3] For example, if a child's placenta is hidden in the canopy of a palm, that might be reason enough to call the child after that palm.

Villages may be named after a plant species (or category) that grows abundantly nearby. Certain villages are given the names of palms: Yeitheri (*Attalea butyracea*), Rashawëtheri and Rashakamitheri (*Bactris gasipaes*) and Konoporipïweitheri (*Iriartea deltoidea*). The reason for naming a village after a plant species (or a category) usually relates to the abundance of the given plant. Similarly, rivers are sometimes named after palms, such as the Yeisipïwei (***yei*** = *Attalea butyracea*). The abundant presence of *Astrocaryum chambira and A. gynacanthum* in the Río Mavaca area is indicated by the fact that the southern Yanomamï (Shamatari groups) call this river Pahana u, which literally means *A. chambira*- or *A. gynacanthum*-river.

MANAGEMENT OF PALMS: EXTINCTION VERSUS SUSTAINABILITY

It is difficult to make generalizations about the sustainability of Yanomamï palm use, because there are big variations in the management of palm resources between communities.

Non-destructive Uses of Palm Trees.—Philips (1993) points out that most preferred palm fruits are difficult to harvest without destroying the trees; yet, the Yanomamï are usually careful not to destroy the fruit-producing palms and have developed certain strategies to collect palm fruits in a sustainable fashion. The collection of the infructescence of *B. gasipaes* (***rasha***), for example, is complicated because the palm is big and the stem is densely spiny. In order to climb up this palm the men employ two kinds of x-shaped scaffolds (***karaki***), each one made of two stems bound together in the middle. This technique is not easy and many young Yanomamï men from villages close to the missions of Ocamo, Mavaca, and Platanal have not mastered it. We observed that instead of climbing the trees, they throw objects at the fruits to make them fall.

We never observed the destruction of a *Mauritia flexuosa* (***eteweshi***) palm because the fruits are collected from the ground or the infructescence is harvested by climbing up the palm. *M. flexuosa* grows in swamps often in dense stands. The Yanomamï occasionally visit *M. flexuosa* stands in order to collect the fruits. According to the headman of the Hasupïweitheri, some *M. flexuosa* populations have human origin; he believes that the seeds were brought there by his ancestors. The consumption of the fruits of small palms, such as *Hyospathe elegans, Geonoma* spp.

and *Bactris simplicifrons* is occasional. These fruits are collected without destroying the palms, mostly by the women and children, who eat them raw.

Destructive Uses of Palm Trees.—It further seems that normally *Attalea* species are not cut down. We observed, however, that *A. butyraceae* were sometimes cut because of the edible larvae that dwell on the decomposing starch of this palm. The rotting trunks and stems can yield up to 4 kg of beetle larvae or grubs per palm.

In contrast to *Attalea,* the species of *Euterpe* and *Astrocaryum* are often cut down. In the case of *Astrocaryum,* the fruits are difficult to harvest and the heart can be eaten when the palm is destroyed.

To make a good bow, the men with superior status in the community cut the young *B. gasipaes* down to use its wood. Because this palm is cultivated for food, we think only high-status individuals who have big garden plots with many palms can afford it. The men with lower status have to find alternative palm wood or obtain it by trade. Once the palm is cut down, the rotting trunk produces an additional protein source, in the form of beetle larvae.

When other food is lacking, the Yanomamï do not hesitate to cut down palms to eat the hearts and to generate a food source for larvae. Vinci (1961) wrote that there were almost no palms around the Shiriana village because the community had cut them all down to eat the hearts. To fell palms in order to harvest hearts and to provide fodder for Coleoptera larvae (e.g., *Rhynchophorus palmarum*) is a common and important habit among the Yanomamï men. This method also has been described among other ethnic groups in the Amazon (Gumilla 1791; Lévi-Strauss 1950). The attraction of Coleoptera larvae in rotting palm wood among the Yanomamï has been described by Chagnon (1968). We observed that the consumption of grubs and beetles obtained from different rotting palms can make up an important part of the overall protein intake. These larvae might contain about 60% protein, 5% unsaturated fatty acids, as well as important nutritional factors like thiamine, zinc, copper, calcium and riboflavin (Duke and Vasquez 1994). We recorded ten palm species with edible beetle larvae that had been attracted to the rotting wood. In the case of *Oenocarpus, Bactris,* and *Euterpe* species the intention of cutting the palms is usually to foster the supply of different larvae that dwell in rotting palm wood. The benefit of cutting down *Euterpe* species is quite big because both the fruits and the heart can be eaten immediately and the rotting wood will eventually yield edible larvae.

We also wondered whether the extensive collection of *Geonoma* and *Bactris simplicifrons* leaves for thatching the communal houses has an impact on the ecology of these palms. Since as many as hundred thousands of leaves are required to thatch a house (Milliken and Albert 1997; Zerries and Schuster 1974), the destructive collection could eradicate whole populations. From what we could observe the leaves are collected individually by the women and children who generally avoid stem collection. It seems that populations might partially recover from extensive collecting. The leaves of ***miyôma*** (*Bactris simplicifrons*) are valued because of their durability. These leaves are even sometimes taken off the old houses to be reused in the construction of the new house, especially if the new living area does not supply these palms.

DYNAMICS OF PALM USE AND IMPACT OF ACCULTURATION

The fact that most Yanomamï groups are semi-nomadic and move their communal house every four to eight years ensures a more sustainable use of palm resources and gives palm populations the chance to recover. Dwelling construction seems to be partly adapted to regional variations of the flora and different cultural demands. Fuentes (1979) provided an impressive example of the dynamics of plant use among the Yanomamï. He describes how the Waputhawëtheri did not find enough *Geonoma* spp. to thatch the house, so that they finally decided to use *Attalea* spp. Because the huge leaves of *Attalea maripa* and *A. butyraceae* were too heavy for the traditional construction the Waputawëtheri were obliged to change the architecture of the roof. In the end, they built a communal house with a roof construction similar to their neighbors, the Yekuana. In a recent visit to the Torithatheri the first author noticed exactly the same phenomenon. The newly built roundhouse, with a diameter of about 85 m, was large enough to provide a landing facility for helicopters. Due to the size of this village there were not enough *Geonoma* spp. for roofing and they decided to employ *Attalea butyracea* leaves. In the Sierra Parima, the traditional roundhouses are protected by outer palisades to add an obstacle to enemies in case of raids (Smole 1976). *Socratea exorrhiza* cannot be sustainably harvested for palisade construction because splitting it destoys the tree. Fuerst (1967) described the use of *S. exorrhiza* planks in the construction of walls at Toototobi. Peters (1998) reports the use of slats from palms (probably *S. exorrhiza*) to make a five-foot vertical wall around the perimeter of the communal house. We observed the use of slats for palisades only in the villages close to the Salesian mission stations Ocamo, Mavaca, and Platanal. These slats, mainly obtained from *S. exorrhiza,* were used to make houses whose form differed from traditional Yanomamï dwellings. The increase of individual private property has imposed the demand for closed dwellings with doors that can be locked. In fact, this is now a very strong factor in the motivation to change traditional architecture.

Acculturation has already induced many changes in the use of palms and will finally result in a changing cultural context of many species. Many palms are now either overexploited because some Yanomamï groups have become sedentary or not exploited anymore because new materials from the mission stations can be obtained. The introduction of zinc and plastic for roofing purposes is an example of the latter. Because the management of wild plant resources within the Yanomamï groups does not seem to be sustainable (see also Finkers 1986; Fuentes 1979), we consider the possibility that more palms have been cut within the last fifty years due to the introduction of machetes and axes. Many palms that are now cut down easily with machetes and axes were not cut at all in the past.[4] The economy of palm usage as such is complex and would certainly need further investigation.

LIST OF PALMS, CULTURAL IMPORTANCE, AND USES

Table 1 summarizes all the palm species discussed in this article. The Yanomamï names are written according to the standard linguistic form used in Ven-

TABLE 1.—Palms recorded among the Yanomamï in Venezuela.

Genus/species (coll. no.)	Yanomamï name	Synonym	Area	Cultural significance
Attalea butyracea (FS 815)	***yei***		O, P, U	4
Astrocaryum aculeatum (JGP 4)	***akiato***		O, P	3
Astrocaryum chambira (JGP1)	***paha***		O, P, U	3
Astrocaryum gynacanthum (JG 133)	***moshihawë***	***moshohawë***	O, P, U	3
Astrocaryum jauari (FS 347)	***moshoha***	***moshoko***	O, P	3
Asterogyne sp. (JGP 11)	***shoko***		O, P	1
Attalea maripa (FS 809)	***kareshi***		O, P, U	4
Bactris aff. *balanophora* (FS 421)	***yohôma***		P	2–3
Bactris gasipaes (FS 814)	***rasha***		O, P, U	4
Bactris maraja (FS 484, JGP 10)	***komorawë***		P, U	3
Bactris simplicifrons (FS 686)	***miyôma***	***mïsïkïri***	O, P	4
Bactris bidentula (JGP 2; JGP 12)	***hoashi mïsi***	***hoashi mosi***	O	2
Bactris sp. 2 (JG179)	***shitipa***		O, P, U	1
Bactris sp. 3 (JG 203)	***hoshekï***		P, U	2
Desmoncus polyacanthos (FS 669)	***mïsïkïri***	***mïsïkïrima***	O, P, U	1
Desmoncus sp. (JGP5)	***mashihire***		P, U	2
Euterpe catinga (FS 715)	***hayakawë***		O, P	3
Euterpe oleracea (JGP 3)	***waima***		O, P, U	4
Euterpe precatoria (FS 797)	***waima***		P, U	4
Geonoma baculifera (FS 802)	***komishi***	***komishïma***	O, P	4
Geonoma deversa (JG 103)	***tharai***	***thaitai***	P, U	4
Geonoma maxima (FS 659)	***thomithomi***		O, P	2
Geonoma sp. (JG176)	***komishi***	***komishïma***	O	4
Hyospathe elegans (JG 88)	***maharawë***		U	2
Iriartea deltoidea (FS 676)	***konopo***	***konoporima***	O, P, U	3
Iriartella setigera (FS 710)	***yoroama***		O, P, U	3
Leopoldinia piassaba (FS 511)	***raea***		P, U	2
Manicaria saccifera (FS 355)	***yawatoa***		O, U	3
Mauritia carana (FS 384)	***moyenarïmi***		P, U	4
Mauritia flexuosa (FS 304)	***eteweshi***		O, P, U	4
Mauritiella aculeata (FS 590)	***torea***		P	3
Mauritiella armata (JGP 7)	***kohere***	***kohare***	P	2
Mauritiella sp. (JGP 8)	***marueti***		P	2
Oenocarpus bacaba (FS 707)	***hoko***		O, P, U	4
Oenocarpus bataua (FS 353)	***haprua***	***hapruawë***	O, P, U	4
Oenocarpus sp. (JGP 6)	***sharapë***		P, U	3
Socratea exorrhiza (FS 821)	***manaka***		O, P, U	4

Coll. no. (collection number): JGP numbers are based on photographs/drawings and do not represent herbarium specimens, whereas JG and FS are herbarium specimens. Area of report: O (Ocamo/Manaviche), P (Platanal/river upwards), U (Sierra Unturán). The cultural significance is an artificial scale constructed from the relative frequency and number of economic and mythological uses of the species: 1 is a palm that is used very occasionally for no more than one use; 2 is a palm not very frequently found or used with more than one use; 3 is a palm frequently found and employed with at least two uses; 4 is a palm with at least three uses and a very high frequency of usage.

ezuela (Mattei-Muller, personal communication).[2] In addition, the table contains data about the area of field observations (origin of reports), as well as an artificial scale of the overall importance of the species.

The following generic list provides information about the context of use of the palm genera. Methods of preparation of palm species and meanings of names are explained. The information presented, if not stated otherwise, has been collected during our fieldwork.

Asterogyne (Uses: construction–leaves). The leaves of an unidentified *Asterogyne* species (***shoko kesi***) were used for the fabrication of a whistle to attract birds.

Astrocaryum (Uses: food–heart, fruits; construction–wood, fruit, leaves, thorns). Provisional shelters (***yano***) built during treks are sometimes covered with the spiny *A. aculeatum* G. Mey (***akiato kë si***) leaves for protection from enemies, evil spirits, and wild animals. The spines also are used to remove skin parasites. Although the heart can be eaten, it is not favored. The fruits are only occasionally eaten. The fruits of *A. chambira* Burret (***paha kë si***) are eaten raw. The endosperm of ripening fruits is consumed as a liquid when young or later as a nut. The fibrous stem wood of this species is sometimes used by the men for the fabrication of the fighting club (***himo***), the usage of which has been described elsewhere (Chagnon 1968). Because *A. chambira* is common in primary forests, its wood is readily available, and except for *Bactris gasipaes* and *Oenocarpus* sp., is most often used in the fabrication of the robust and durable bow. The pericarp of the fruits is used by children to make spinning tops, which are also called ***paha*** like the palm. The women make toys for little children from the tough endocarp. *A. chambira* is common in the upper Rio Mavaca and Sierra Unturán region as well as along the Rio Ocamo.

The fruits of *A. gynacanthum* Mart. (***moshihawë kë si***) are eaten roasted and the slightly sweet heart is eaten cooked like a vegetable (Figure 4). The somewhat smaller orange-reddish fruits are prepared for food like *A. chambira*. We collected a voucher specimen in the Sierra Unturán, where this species is frequent.

The palm heart of *A. jauari* (***moshôa kë si***) is edible, the spines are removed from the wood so that it can be used in the construction of the houses (***yahi***).

Attalea (Uses: food–fruits; seed, larvae; construction–leaves, spathes). The endocarp of the fruit of *A. butyraceae* (Mutis ex L.f.) Wess. Boer (***yei kë si***) is eaten in great amounts (see Figure 5). The seed also is opened and the inner part is eaten. The leaves are sometimes used in the roundhouse to make provisional walls between the compartments. The leaves are more and more used to thatch the communal houses due to overexploitation of the leaves of *Geonoma* spp. normally used. With the young leaves of *A. butyraceae* the ceremonial crowns (***watoshe***) of new shamans are fabricated. The rachises of the leaves are used to make little arrows (***kareshi masiki***) for the boys. *A. butyraceae* also serves for the construction of the cotton spindle (***ruhu masi***) and provides little sticks to perforate the earlobes of children. Edible beetle larvae (***oõu oki***) live in its rotting wood.

The mesocarp of ripe fruits of *A. maripa* (Aubl.) Mart. (***kareshi kë si***) is eaten in great amounts between July and October and is therefore an important food source during the rainy season. The fallen fruits are collected and the kernels are left in water for up to several days, boiled and then opened to eat the small seeds. ***Kareshi*** heart is occasionally eaten on treks. The *A. maripa* leaves (***masiko***) are used in the ***shapono*** to raise little walls for protection against the sun or from the neighbors. Sometimes, the leaves are used to thatch the roofs of smaller houses.

FIGURE 4.—Infructescence of *Astrocaryum gynacanthum* (**moshihawë**), which is roasted and cooked before consumption.

The petioles of the leaves are used by boys to make little arrows (**kareshi masiki**) and they also serve in the making of spindles for cotton (**ruhu masi**) and as the little sticks for perforating the earlobes of children. The spathes are folded and sewn together at each end to provide a container for food or trash.

Bactris (Uses: food–fruits, heart, larvae; construction–wood, leaves, fruits). The mesocarp of the fruit of *Bactris* aff. *balanophora* Spruce (**yohôma**) is eaten raw, mostly by women and children. Boys use the leaf petiole to make little arrows, which they use to hunt small birds.

The spiny-trunked palm *B. gasipaes* Kunth (**rasha kë si**) with hard dark wood has in many cases lost the capacity to produce fertile seeds and is reproduced by planting sprout cuttings (Sauer 1950). The fruits are greatly appreciated in all the

FIGURE 5.—Yanomamï woman preparing tobacco leaves, the fruits of *Attalea* sp. on the floor serve as occasional snack.

Yanomamï communities (Figure 6). The mesocarp is consumed because it has a pleasant taste and possesses a high nutritional value. According to Popenoe and Jimenez (1921), the cooked fruits contain 40.9% carbohydrates, 6.7% fatty acids, 2.8% proteins and 48.8% water. The nutritional value is more than twice that of plantains (*Musa* spp.). This species does not appear to occur wild but is cultivated in swidden clearings throughout the Yanomamï territory. Reports about wild palms (Zerries and Schuster 1974) probably just concern old garden populations (Figure 7). This palm is usually grown in the older part of the garden, which is called the anus of the plot (***posi kë thëka***). Each palm might produce up to 120 kg of fruit per season. From January until March, when *B. gasipaes* produces most of its infructescences, the Yanomamï often invite neighboring communities to celebrate the ***reahu*** feast. The men prepare the ***rasha*** fruits for the guests. This feast

FIGURE 6.—Infructescence of *Bactris gasipaes* (***rasha***) ready for transportation.

is associated with funerary celebrations of related groups and strengthens the alliances between communities. Although ***rasha*** fruits play a certain role during ***reahu***, it is not true that ***reahu*** is the feast of the ***rasha*** fruits as proposed earlier (Eibl-Eibesfeldt 1972).

We could distinguish at least four cultivated forms of *B. gasipaes*: 1) ***rasha auaurimï*** (also ***rasha yoararomi***), which has greenish-yellow epicarps. This cultivated form can also be eaten raw because it has a nice sweetish taste; 2) ***rasha tapïtapïrimï*** with yellow fruits; 3) ***rasha wakëwakërimï***, with dark reddish fruits; and 4) ***rasha ahu mopë***, an apocarpic form with green-reddish fruits. Each palm produces two main harvests, the main one during December to March and another smaller one in August. When the palms get old and do not produce good infructescences anymore, they are cut. The sweetish and soft heart is then eaten. The women make adornments for their ear lobes with the young leaves by tearing them into fine strips. The men make their bows with the wood. According to them, the wood of *B. gasipaes* is best suited for the construction of the bow (***hato***). The poisonous arrow points (***husu kë namo***) are made of this wood, although the preferred wood seems to be from *Iriartella setigera*. The women use a stick (***rasha husi***), usually made out of an old bow as a tool for garden work and also for self-defense. In the old trunks and stems the Yanomamï always look for edible beetle larvae. The trunk of *B. gasipaes* is habitat for tasty larvae called ***oõu okï***.

The leaves of the small palm *B. simplicifrons* Mart. (***miyôma kë si***) are used to wrap all kinds of objects, including small animals, and fruits. In the Siapa area the roofs of the communal houses (***shapono***) are said to be made entirely out of *B. simplicifrons* leaves. The leaves of ***miyôma*** sometimes bear spines, but occur

FIGURE 7.—Cultivated *Bactris gasipaes* palm of a garden plot in Irokai.

more frequently unarmed (Stauffer and Briceño 2000). The palm grows in large populations in nonflooded places in rain forests and is frequent to the south of the Sierra Unturán. The small fruits are occasionally eaten during long walks, mainly by women and children. In order to store the fresh snuff mass made of the seeds of *Anadenanthera peregrina* (Fabaceae) the men use ***miyôma*** leaves. The leaves are also used to make a kind of funnel for the preparation of curare. It seems that the leaves of *B. simplicifrons* are also most suited to store diverse products employed in sorcery. Women often wrap up the placenta of a new born child in the leaves of *B. simplicifrons* in order to make a package, which is hidden. In the past, the little fruits were used to make collars.

The heart and fruits of *Bactris bidentula* (***hoashi kë mosi***) are edible, the endocarp is eaten raw, and the wood is sometimes used to make the Yanomamï bow. ***Hoashi (kë) mosi*** can be translated as "palm of the penis of the capuchin monkey (*Cebus nigrittatus*)." The palm is also cut to provide fodder for edible beetle larvae.

Shitipa kë si (unidentified) is a common *Bactris* species without particular use. The Yanomamï of the upper Ocamo think that it is a kind of degenerated *B. gasipaes* (***rasha***) palm because it does not produce edible fruits. According to our informants in Ocamo the wood can be used to make bows. The palm is cut to provide fodder for edible beetle larvae. Another unidentified species is ***hoshekï***, which produces fruits that are eaten raw. The fruits of *B. maraja* Mart. (***komorawë***) are suitable for eating, although they are not particularly tasty.

Desmoncus (Uses: food–fruits). According to the women, the fruits of an unidentified *Desmoncus* species (***mashihire kë si***) are edible, though not very tasty. These fruits were occasionally eaten by the women and children of Mokaritha, mainly during walks in the forests. No uses are recorded for *D. polyacanthos* Mart. (***mïsïkïri kë si***).

Euterpe (Uses: food–fruits, heart, larvae; construction–leaves). *E. catinga* Wallace (***hayakawë***) is somewhat smaller and not as common as *E. precatoria* Mart. (***waima kë si***). The heart, leaves and fruits of both palms are used in the same way. The fruits are soaked in water and then extracted to prepare an aromatic and sweet purple drink. Some Yanomamï groups of the upper Orinoquito use the pigment obtained from the purple fruits to make face and body paint. The heart of this palm is appreciated because it is sweetish and soft when cooked. The leaves are used in the construction of the communal house at the end of the roof that faces the open space in the middle. The leaflets hang down from the end of the roof to ensure that no rain enters the inside of the roof. During the ***reahu*** feast the ***waima*** leaves are halved and used in dances. The rotting stem wood provides fodder for edible beetle larvae.

Because *E. oleracea* Mart. (***waima kë si***) is not normally found in the Venezuelan Amazon, we assume that it has been introduced by the Brazilian Yanomamï to some neighboring groups. *E. oleracea* produces many stems, each one growing a heart, so this palm is appreciated as a source of edible hearts. It is not present along the middle and upper Orinoco but has been recorded from the lower eastern Sierra Parima.

Geonoma (Uses: food–fruits; construction–leaves). The abundant palm *Geonoma baculifera* (Poit.) Kunth (***komishi kë si***) grows in huge populations in the forests of the upper Orinoco, especially to the north, along the Orinoquito, Manaviche and Ocamo rivers. The leaves are considered ideal for wrapping up smaller pieces of food to cook them in the fire. ***Komishi*** leaves resist the heat of the charcoal and are therefore often used to prepare food. The leaves also are often used to thatch the roof of the traditional communal house. In addition, these leaves are used to make a funnel to separate the bone powder from the bone pieces, which have not yet been pulverized properly. The bones of the dead need to be crushed and pulverized since the Yanomamï funerary ritual demands the ashes (including bone powder) to be eaten by the relatives. This *Geonoma* species is a typical ***mïshikï*** (material for thatching or weaving).

The leaves of *G. deversa* (Poit.) Kunth (***tharai kë si***) are used frequently in the construction of the roofs of the communal houses. The palm is more abundant to the north of the upper Orinoco and it is also often used to wrap up food to roast in the coals. During long walks, the fruits are occasionally eaten by women and children.

The leaves of *G. maxima* (Poit.) Kunth (***thomïthomï kë si***) are used in the same manner as the ones from *G. deversa*. The name ***thomïthomï*** is associated with the picure (*Dasyprocta* spp.), which is called ***thomï***.

Hyospathe (Uses: food–fruits, heart; construction–leaves). The fruits of *H. elegans* Mart. (***maharawë***) are eaten raw, especially by the women and children. The small heart is also edible. Despite the fact that this palm is known by the other communities, we could only record its use in Mokaritha. As with the leaves of *Geonoma* spp., those of this palm are used to wrap up little objects. When there is no other material the leaves of ***maharawë*** are also used to thatch the roof of the communal house. This palm is quite abundant towards the Sierra Unturán and in the southern Sierra Parima, and according to our informants, also along the Río Ejército.

Iriartea (Uses: food–heart; construction–stilt roots, spathe; medicine–leaves). The heart of *Iriartea deltoidea* Ruiz and Pav. (***konopo kë si***) can be eaten, but it is not tasty. In the olden days the Yanomamï made their hammocks out of the stilt roots of *I. deltoidea*. They took a long stilt root, cleaned the spines from it, and beat it with a stone until the fibers came out. The fibers were left attached at the ends to provide a hammock. (They do not weave the fibers together; therefore, it is sometimes easy to fall through the fibers!) The spathe, which can be found on the ground, is used to make small bags, which are called skin of the ***konopo*** (***konoposi***) or ***karaha***. These bags are used by the men to store feathers, monkey skins and other ornamental utensils (***paushi***). In the myth of the big deluge (***motu pata***), the Yanomamï tried to save their lives by hanging their hammocks in the ***konopo*** palms. The young sprouting leaves are used against the bites of the poisonous ant ***shihô*** (*Euponera* sp.). The sprouts are squeezed and put onto the spot that hurts.

Iriartella (Uses: construction–wood, leaves). The wood of the small palm *Iriartella setigera* (Mart.) H. Wendl. (***yoroama kë si***) is used to make the poisonous arrow points (***husu kë namo***). Interestingly, the name for blowgun is also ***yoroama***. It is noteworthy that blowguns are not used among the central Yanomamï. According to our informants, the wood of *I. setigera* is particularly suited to make the poisonous arrow points because it already contains a lethal power. In the mythology the acquisition of curare is related to a blowgun (***yoroama***) and it is possible that the Yanomamï men therefore prefer ***yoroama*** wood for that purpose. Boys make little arrows (***ruhu masikï***) from the leaf rachis.

Leopoldinia (Uses: food–fruits; construction–leaves). The fruits of *Leopoldinia piassaba* Wallace (***raea kë si***) are sometimes eaten raw, especially when other food is scarce. Around the mission in Ocamo, we could observe that the leaves of *L. piassaba* were used to thatch the non-traditional houses. The fibers of the stem can be used for the fabrication of the ceremonial crown (***watoshe***) for the initiation of a new shaman.

Manicaria (Uses: food–fruits, larvae; construction–leaves). The immature seeds of *Manicaria saccifera* Gaertn. (***yawatoa kë si***) are eaten raw. The leaves are used to cover objects and to provide protection from dust. Rotting stems are always investigated for edible beetle larvae. Because this palm is more frequent in the upper Mavaca the resident groups of that area more often use the fruits as food. The rotting wood provides fodder for edible beetle larvae.

Mauritia (Uses: food–fruits, larvae; construction–leaves). The mesocarp of the fruit of *Mauritia carana* Wallace (***moyenarïmi kë si***) is edible and different in taste from *M. flexuosa* L.f. (***eteweshi kë si***). The pulp of the fruit is reddish and less sour than ***eteweshi***. The rotting wood provides fodder for edible beetle larvae.

The mesocarp of the ripe (***okoroshi***) fruits of *M. flexuosa* is eaten raw. The infructescence is cut and left in the water for some days before collection. The pulp is also gathered to make a broth with water. Since there are many *M. flexuosa* populations (*morichales*) in the Venezuelan Amazon, the fruits are quite frequently consumed. Edible beetle larvae also live in the rotting wood of this starchy palm. The petiole of the leaf is used by boys to make small arrows. The split petioles are used for weaving simple baskets (***yorehi*** type) that are employed to store food and detoxify cooked ***wapu*** fruits (*Clathrotropis* spp.), which are soaked in water. The women use the young leaves to make ear ornaments (***hoko sikï***).

Mauritiella (Uses: food–fruits; construction–wood, leaves). The fruits of *Mauritiella armata* (Mart.) Burret (***kohere kë si***) are eaten infrequently. The petiole of the leaf is used by boys to make little arrows. The women use the young leaves to make ear ornaments (***hoko sikï***).

The fruits of *M. aculeata* (Kunth) Burret (***torea kë si***) are edible. With the wood of this palm the men fabricate a certain type of arrow point (***ãthãri***) to hunt big birds and monkeys. The young leaves are seldom used to make ear ornaments.

Oenocarpus (Uses: food–fruits, larvae; construction–leaves, wood, petioles). The fruits of *Oenocarpus bacaba* Mart. (***hoko kë masi***) are important in the Yanomamï diet, especially because they fruit primarily during the rainy season. From the mesocarp of the fruit a thick broth is obtained, which is diluted in water to prepare a drink. The stems of *O. bacaba* are used in the construction of the communal house and its wood is occasionally employed in the fabrication of bows. The young leaves are torn into fine strips by women and girls to make earlobe ornaments, which are called ***hoko sikï***. These ornaments are worn during the initiation ritual of the women. ***Hoko siki*** literally means ***hoko*** palms and denotes all the ornaments made out of palm leaves. Men use half leaves of *O. bacaba* during feasts, where they are lifted up and moved down during the presentation dances (***praïaï***). Woven screens are made from the leaves as protection from the sun or for privacy in the communal house. In the rotting wood live beetle larvae (***potimani***) which are eaten.

The infructescence of *O. bataua* Mart. (***haprua kë si***) is frequently harvested by the men. The fruits are cooked in water, the epicarp is discarded, and the

FIGURE 8.—Stilt root of *Socratea exorrhiza* (**manaka**), formerly used in the fabrication of hammocks.

mesocarp is prepared as a drink. The ripe mesocarp is also macerated in hot water for one or two hours. The resulting soup is consumed raw or cooked. The leaves are used to make provisional shelters within the communal house as well as walls for protection. For this purpose the leaves are woven together. The women make a kind of fan (***shuhema***) with the small leaves. It is used to fan the coals when making fire and also to sweep the floor. The leaves are used to wrap up the dead for transportation. The split petioles are used for weaving simple baskets that are employed (lined with leaves) to store food and to detoxify the cooked ***wapu*** fruits (*Clathrotropis* spp.), which are soaked in water for several days.

An unidentified species (***sharapë***) also produces edible fruits. According to our informants it is similar to *O. bataua* but not as frequent.

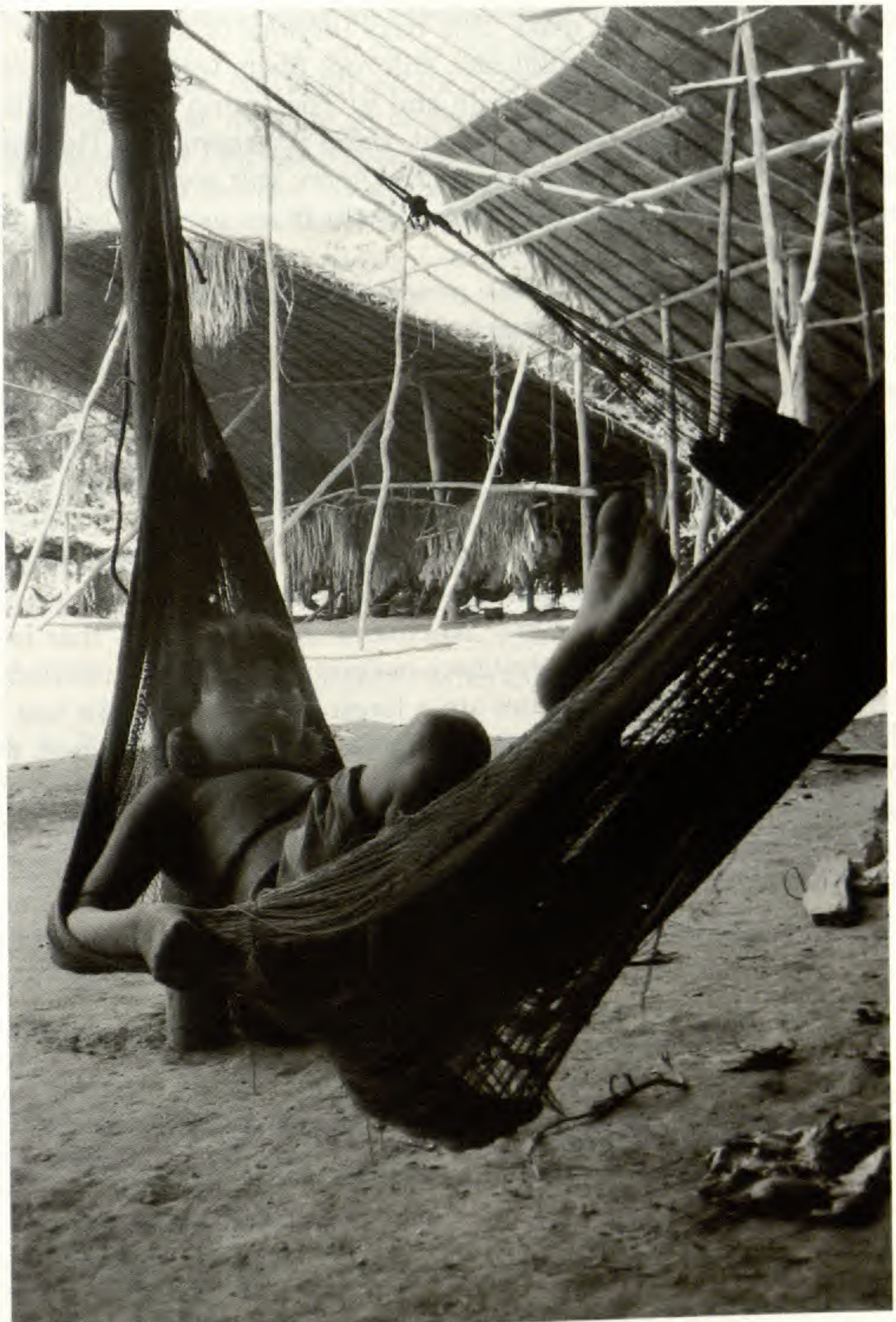

FIGURE 9.—Girl in hammock in the village Hasupïwei showing (in the back) the structure of the roundhouse with palm thatched roofs.

Socratea (Uses: construction–wood, spathe; medicine–young leaves). The stems of *Socratea exorrhiza* (Mart.) H. Wendl. (***manaka kë si***) are usually employed in the construction of the communal house. The mythological importance of ***manaka*** has already been described above. The stem wood is occasionally used in the fabrication of bows. According to Valero (1984), the men use sanded and pointed pieces of the stem as wooden rods in duels. The spathe of the inflorescence is sown together at the ends and used to press out fruits to make juice. The fruits are put into the bag-like press and squeezed until the juice gathers in the bag.

The spathe is further used to make little bags (***karaha*** or ***konoposi***) to carry all sorts of objects. As with *Iriartea deltoidea,* stilt root fibers were left attached at the ends to provide a hammock (Figures 8 and 9) The young sprouting leaves are used against the bites of the poisonous ant, ***shihô*** (*Euponera* sp.). The sprouts are squeezed and put onto the hurting spot. The spiny stilt roots are used to open, grind and rasp the ***tana*** fruits (*Genipa* spp.), which are used as body paint (Fuentes 1979).

DISCUSSION

Anderson (1978) states that the Yanomamï (Shirianatheri) exploit palms to a far lesser degree than do other South American tribes. We think that this conclusion might have been derived partly because of the limited duration of his fieldwork. Anderson has correctly pointed out, however, that regional differences in the distribution of palm populations force the indigenous groups to look for substitutes, and that in certain areas palms have been overexploited and are no longer available. While it is true that some Yanomamï dwell in areas that lack palm diversity, this does not mean that they have necessarily lost their knowledge about palms and their uses. The Yanomamï are a forest people and make use of many of the plant species available. Given the abundance of palms in the area, this plant family provides an ideal resource for a semi-nomadic people. The importance of palms as food is already shown by the fact that most palms produce edible fruits or hearts. In addition, the starchy wood of more than ten palms serves as fodder for beetle larvae, which are eaten in great amounts by all the Yanomamï groups visited. In this study we have shown that the Yanomamï generally employ more then half of the palm species present in the area as food, construction material, magic and medicine.

NOTES

[1] VEN: Herbario Nacional de Venezuela; NY: Herbarium of the New York Botanical Garden, Bronx; US: National Herbarium of the United States of America, Smithsonian Institution, Washington DC; MYF: Herbario V.M. Ovalles de la Facultad de Farmacia, UCV, Caracas; TVAF: Herbario J.A. Steyermark del MARNR, Pto. Ayacucho; PORT: Herbario de la UNELLEZ, Guanare; MER: Herbario de la Facultad de Ciencias Forestales (ULA), Mérida; GUYN: Herbario del Jardín Botánico de Ciudad Bolívar, Ciudad Bolívar; CAR: Herbario de la Fundación La Salle de Ciencias Naturales, Caracas.

[2] Prof. Dr. Marie-Claude Mattei-Muller, Apartado 17277, Parque Central, Caracas 1015.A, Venezuela.

[3] Taped interview with Helena Valero in her home near Ocamo, August, 28,1998.

[4] Taped interview with Helena Valero in her home near Ocamo, August, 28,1998.

ACKNOWLEDGMENTS

Fieldwork was made possible through a scholarship from the Swiss Agency for Development and Cooperation (DEZA). Thanks go to Prof. Dr. Sir Ghillean Prance, who generously supported and supervised the ethnobotanical fieldwork, and also reviewed the manuscript. The project is based on an international contract between the Ministry of Environment in Venezuela (MARNR) and the Swiss Federal Institute of Technology (ETH) in Zurich. Special thanks therefore go to the Dirección de Asuntos Indígenas (DAI) for helpful discussions and Prof. Dr. Stephen Tillett from the Herbario Ovalles (UCV), who not only provided work facilities but also supplied helpful literature and relevant ethnobotanical data. Permits were obtained according to the Decisión 391 from MARNR, INPARQUES, D.A.I, as well as ORPIA and the Guardia Nacional. Without the help and consent of the Yanomamï communities around Ocamo, Aratha, Mahekotho, Hasupïwei, Irokai and Mokaritha, we certainly could not have carried out our fieldwork. The first author wishes to express his gratitude to the main informants Moshawë (Augustin), Niomawë (Nicolemo), Kouwë, Shamathari and Nikêro for their indispensable help and teaching. Gratitude is due to Helena Valero (alto Orinoco) for her hospitality and interesting discussions about plants in Yanomamï culture. Finally, the manuscript was reviewed by Prof. Dr. Marie-Claude Mattei-Muller, who further corrected the linguistic data and engaged in stimulating discussions.

This paper is dedicated to the memory of Kouwë, the former headman of Hasupïwei, who died in December, 2001.

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Journal of Ethnobiology 22(2): 247–272 Winter 2002

TZOTZIL MAYA ETHNOECOLOGY: LANDSCAPE PERCEPTION AND MANAGEMENT AS A BASIS FOR COFFEE AGROFOREST DESIGN

FABIO PEDRO S. DE F. BANDEIRA,[a] JORGE LÓPEZ BLANCO[b] and VICTOR M. TOLEDO[c]

[a] *Departamento de Ciências Biológicas, Universidade Estadual de Feira de Santana, Km. 3, Br 116, Campus Universitario, Feira de Santana, Bahia, Brasil, CEP 44031-460*
fpbandeira@uefs.br

[b] *Instituto de Geografía, UNAM, Ciudad Universitaria, Coyoacán, CP 04510, México, D.F., México*
jlblanco@servidor.unam.mx

[c] *Instituto de Ecología, UNAM, Apartado Postal 41-H, Sta. María de Guido, Morelia, Michoacán, 58090, México*
vtoledo@oikos.unam.mx

ABSTRACT.—In Los Altos de Chiapas and other regions of Mexico, indigenous producers maintain multilayered, rustic coffee agroforests (RCAs). Focused on Polhó (municipality of San Pedro Chenalhó), a Tzotzil Maya community, indigenous ecological knowledge and landscape categorization relevant to the design and establishment of RCAs were identified. The methodology involved: 1) structured interviews with 50 coffee growers encompassing ecological knowledge (soils, microclimate, vegetational units, and succession) and management history of RCAs; 2) collection of vouchers of vascular plants having ethnobotanical importance; and 3) identification of plants within one hectare of an RCA. As a result of their multiple-use strategy of natural resource management, Tzotzil informants perceive several vegetational units, soils, and microclimatic conditions. Tzotzil ecological knowledge is critical to the design and establishment of an RCA, especially regarding ecological succession. Two common routes for RCA establishment were observed: 1) from other cultivated fields (predominant source); 2) from secondary vegetation. Coffee growers' activities such as protection/promotion of native trees, cultivation of crops and nitrogen-fixing trees, and elimination of pioneer species seem analogous to processes of ecological succession.

Key words: Tzotzil, rustic coffee agroforests, ethnoecology, ecological succession, landscape management.

RESUMEN.—En la región Los Altos de Chiapas, y en otras partes de México, los productores indígenas mantienen sistemas agroforestales rusticos multi-estratificados SAR). Centrado en Polhó (municipio de San Pedro Chenalhó), una comunidad Tzotzil Maya, fue estudiado el conocimiento ecológico indígena y la categorización del paisaje que es relevante en el diseño y construcción de los SAR. La metodología incluyó: 1) entrevistas estructuradas con 50 productores de café sobre su conocimiento ecológico (suelo, microclima, unidades de vegetación y sucesión), y la historia de manejo de los SAR; 2) colecta y herborizacion de plantas vasculares y la información etnobotánica; y 3) identificación de las plantas en un hectárea de SCA. Como resultando de las estrategias de uso para el manejo de los recursos naturales, los informantes Tzotziles perciben diversas unidades de vegetación, suelos, y condiciones microclimaticas. El conocimiento ecológico de los Tzotziles es crítico para la construcción de los SAR, siendo el conocimiento ecológico de la sucesión lo más importante. Fueron observadas dos rutas para el establecimiento de los SAR: 1) desde otro terreno cultivado (la condición dominante); 2) desde la vegetación secundaria. Las actividades que realiza el productor de café (protección/promoción de árboles nativos, el cultivo de especies domesticadas y fijadoras de N, la eliminación de especies colonizadoras y pioneras) parecen ser análogas al proceso de sucesión ecológica.

RÉSUMÉ.—Dans certaines régions du Mexique comme les hauts plateaux du Chiapas, les producteurs indigènes pratiquent un système d'agroforesterie naturelle et stratifiée de café—agroforêts naturelles de café (ANC). Cet article examine les connaissances écologiques et les méthodes indigènes de classification du cadre naturel utilisées par une communauté maya tzotztil de la région de Polhó (municipalité de San Pedro Chenalhó) pour la conception et la création d'agroforêts naturelles de café. La méthodologie de ce projet était la suivante: 1) interviews structurées de 50 producteurs de café portant sur les connaissances écologiques (sols, microclimats, unités de végétation, et succession) et l'historique de l'établissement des agroforêts naturelles de café; 2) collecte d'exemplaires de plantes vasculaires importantes d'un point de vue ethnobotanique; et 3) identification des plantes recensées dans un hectare d'agroforêt naturelle de café. Parce qu'ils exploitent les ressources naturelles de multiples façons, les producteurs tzotzil interviewés définissent plusieurs catégories de paysage (unités de végétation), sols, et microclimats. Le savoir écologique des Tzotzil est essentiel à la conception et à l'établissement d'une agroforêt naturelle de café, particulièrement en ce qui concerne la succession écologique. On a observé deux démarches courantes pour la création d'une agroforêt naturelle de café: 1) à partir d'autres champs cultivés (source principale); 2) à partir de végétation secondaire. Les activités des producteurs de café, comme la protection/amélioration des arbres indigènes, les culture vivrières, les cultures d'arbres fixateurs d'azote, et l'élimination d'espèces pionnières, semblent correspondre au processus de succession écologique.

INTRODUCTION

In the coffee-growing regions of Latin America, forest exploitation ranges from little disturbed natural forests to agroindustrial, monospecific plantations. Between these two extremes are the rustic coffee agroforests under indigenous management. In Mexico, the coffee crop is dominated by traditional small-scale growers both in terms of the number of cultivators and the total amount of land planted in coffee (Moguel and Toledo 1999). As in other regions of Latin America (Perfecto et al. 1996), these coffee growers maintain multilayered, shaded coffee agroforests that combine relatively high and sustainable economic benefits with a seemingly diversified, productive system. In the rustic coffee system, coffee bushes substitute the plants growing on the floor of mature and/or secondary forests. The result is an exuberant coffee garden with a great variety of arboreal, shrub-like, and herbaceous species, both wild and domesticated.

Because indigenous ecological knowledge is critical for the construction of

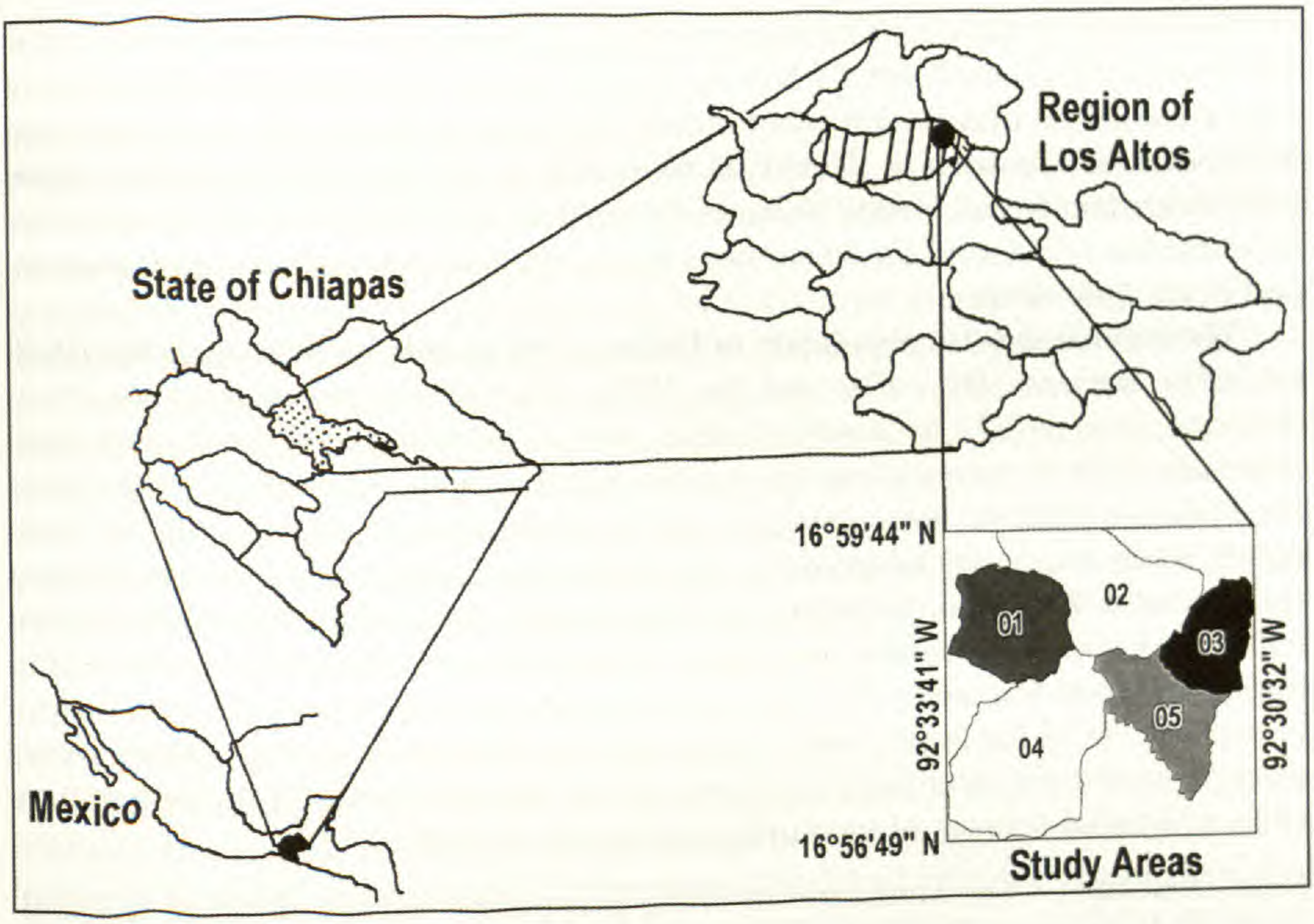

FIGURE 1.—Location map of Polhó, Chiapas.

these rustic coffee agroforests, this paper is devoted to exploring by a case study how indigenous producers employ their perception of soils, climate, vegetation masses, plant species and ecological processes, in order to create and manipulate these coffee gardens.

The Study Site.—The study area is located in the Los Altos de Chiapas region between 19°59′49″ and 19°59′44″ N latitude, and 92°33′41″ and 92°30′32″ W longitude (Figure 1). It lies within the municipality of San Pedro Chenalhó, whose name is partly derived from Tzotzil, ***Chenalhó*** 'water well'. This study area encompasses 1837.6 ha of the total 130 km^2 (about 13%) of the municipality of Chenalhó. Five subareas with contrasting environmental conditions were selected for this study. These include all of the land associated with the studied community, Polhó, as well as a small extension of land belonging to the Tzotzil communities of Tzajalukum, Acteal, Poconichin, Narajantik Bajo, Narajantik Alto, Yabteklum, and Yebeljoj.[1]

In the northern sector of the municipality of Chenalhó, where Polhó is located, the climate is of the type (A)C(m)—sub-warm-humid with abundant summer rains, as defined by the Köppen classification since modified by García for Mexico (SEGOB 1988). The average temperature in this zone where coffee thrives ranges from 18 to 22°C, and the annual rainfall is between 2000 and 2500 mm. Geomorphologically, the study area is defined by steep mountainsides, formed by folded structures of Cretaceous limestone, and similarly sheer high hills. In the structurally controlled valley bottom there are some alluvial plateaus of Quaternary age.

Predominant soils in the area, particularly in subareas 1, 2, 4, and 5, are orthic and chromic luvisols (INEGI 1991). Such soils have a characteristic B horizon of clay, are shallow, and exhibit low fertility. Rendzina soils are the dominant type in subarea 5. The area is devoid of navigable rivers and the vegetation types present are coniferous forests (subarea 3) together with fragments of cloud forests (in subareas 1, 2, 4, and 5), which have been deeply altered by centuries of slash-and-burn agriculture.

The estimated total population of Polhó is 399 people in 78 households (INEGI 1991). Between the 1970s and the 1990s, Chenalhó's population more than doubled, from 13,522 to 30,680 (INEGI 1991). The houses are built with local materials, such as clay and wood, and are hay-thatched, although in recent years the building patterns have changed and concrete houses with metallic or cardboard roofs are being adopted. In the 1990s, the people of Polhó proclaimed themselves a Zapatista Autonomous Municipality as a result of a confrontation between them and Chenalhó municipal authorities, who have a close relationship with local rulers (*caciques*). This close relationship has perpetuated the long history of exploitation of the local people. Moreover, the emergence of paramilitary forces since 1996 and the more active presence of the Mexican army in the region have been additional sources of insecurity and social conflict.

Local Landscapes.—The landscape in Polhó is a patchy mosaic of *milpas* (polycultural fields in which the main crop is maize), home gardens, diversified groves for shaded coffee, a few specialized shaded coffee plantings, *potreros* (grazing grasslands), banana and sugarcane plantings, fallow fields, and forests in various stages of ecological succession. The dominant floristic elements of these forests separate them into two types of secondary vegetation: 1) the *acahuales*, in which tropical elements are dominant and which occur in the northern zones encompassing subareas 1 and 2; and 2) secondary vegetation with conifers, which includes subareas 4 and 5 to the south and subarea 3 to the west. The surface covered by mature coniferous and cloud forests is nowadays very narrow. The coniferous forests in the more temperate areas have an extension of 26 ha of conserved woodland, and 30 ha of altered woodland (F. Bandeira et al. in press). These two fragments of forest, which were located in the more elevated and protected areas, crowned the landscape until 1997, when they were largely cut down by the Mexican army, and to a lesser extent, by 2500 newcomers who had been displaced from their original communities (Unión Majamut, personal communication, 2000) as a result of the 'Zapatista' conflict in the region (Collier et al. 1994). These immigrants settled on these lands after a massacre carried out by paramilitary groups in December 1997 in the community of Acteal, near the study site.

Majomut: an Indigenous Coffee Grower Organization.—The Unión de Ejidos y Comunidades Beneficio Majomut is an organization that is mostly composed of organic and conventional coffee growers from the municipalities of San Pedro Chenalhó and San Juan Cancuc, in the northern part of the Los Altos de Chiapas region. In these municipalities, people live in several dispersed settlements or *parajes*, which are the basic units of the community; each one of these harbors between 20 and 200 households (Majomut 1983). The main modes of land tenure are a Mesoamerican communal property regime (the prevailing mode) and the *ejido* (an institutional land tenure system created by the Mexican state in the beginning of the twentieth century to distribute land to rural communities); privately owned estates are less common (INEGI 1991). By custom, land use rights may change hands in two ways. Privately owned land is simply inherited from father to son. Less commonly, the use of communally owned land is allocated by traditional authorities. The average size of individual properties is 2 ha, with a trend towards extreme reduction and spatial dispersion of agricultural fields.

Even though the land is communal property, each coffee tree has an owner. Production is organized by family: the coffee crop is sold and the products of the milpa are kept for home consumption. These activities are the basis of the economy of the community of Polhó. Rain-fed cultivation for subsistence occupies a central role in this agricultural production system, mostly in the form of milpas; milpas are interplanted with beans, squashes, and chili, and these crops are supplemented by gathering tolerated weedy species considered edible—*quelites*. These milpas—a common feature of Mesoamerican agriculture—are based on slashing and burning mature or secondary vegetation, with cultivation cycles punctuated by relatively long fallow periods for restoring soil fertility and for reducing populations of unusable weedy plants, pests, and plant pathogens. In contrast, coffee growing is much more recent. Coffee was introduced into the region less than 100 years ago and adapted to the Maya *solares*, permanent gardens including useful trees, shrubs, herbs, climbers, epiphytes and annuals, which are owned by a household, and whose produce is either for home consumption (most) or the market. It was the grandparents and parents of the current producers who brought the shrubs from the coffee *fincas*, privately owned large rural estates, in Soconusco, where they were employed as *jornaleros* (day laborers). Only in the twentieth century was coffee cultivation incorporated into the indigenous food production system, and it has played a significant role in the economy of the region during the last four decades.

The coffee growers of Polhó are Tzotzil who have ancient roots in the land. This research builds on earlier studies of Tzotzil culture, including. studies of Tzotzil cosmology (Jacorzynskl and López-Hernández 1998; Vogt 1964), ethnobotany (Breedlove and Laughlin 1993), and various other ethnographic, anthropological, historical, and socioeconomic topics (Collier 1990; Laughlin 1969; Nigh 1989; Parra-Vázquez 1993a; Wasserstrom 1989).

METHODS

General Survey.—During December 1996 (15 days) and March (15 days), an initial general survey of the area was carried out in all of the communities belonging to Majomut, with the purpose of selecting one of these communities for study. We interviewed delegates and leaders of each community visited in order to explain the objectives of the research to be conducted. After this, the community of Polhó was selected for more detailed study, based on geographical criteria (its ecophysiographic heterogeneity), geopolitical status (its relevance of the community at the regional level, and its spatial relations with other communities within Majomut), its diversity of production (productive and landscape managing strategies observed), and the apparent physiognomic diversity of its coffee agroforests.

We conducted an environmental inventory of the Tzotzil territory accompanied by local farmers and reviewed the extant literature. Also, a photographic record was made of the landscape and of the several land uses in the eight local geographical demarcations, or *barrios,* of Polhó: Majomut 1, Majomut 2, X'oyep 1, Xoyep 2, Polhó Centro (Central Polhó) Canolal, Majunpenpetik 1, and Majunpenpetik 2.

Detailed Survey.—The specific methods employed in the detailed survey of the coffee agroforests of Polhó and of the ecological knowledge of its designers and actors were the following:

1) Structured interviews (Alexíades 1997) were carried out between June and July, 1997 (60 days) with 50 of the 173 local organic coffee producers. These structured interviews had the objective of eliciting local knowledge about the ecology (classification of the landscape or management units, of the phases of ecological succession, and of the vegetation types), pedology (classification of soil types), and climatology, following the system of Toledo (1990). Additionally, the surveyed producers were questioned about their practices of management of the coffee agroforests and of soil conservation, as well as about other ethnoecological data, such as the number, surface and location of their management units. These interviews were carried out in the plots of each producer surveyed, either in Spanish or in Tzotzil, with the aid of a bilingual worker from Majomut or an organic coffee promoter.[2]
2) Voucher specimens were made of all trees, shrubs, vines and herbs growing on a one-hectare plot of coffee agroforest in Polhó. Each specimen was accompanied by its corresponding Tzotzil and Spanish names, use, and parts used. The specimens were identified by the staff of the Herbarium of the Faculty of Sciences, UNAM (FCME), where they are housed.
3) For all surveyed plots, data were recorded on their history of management, such as past uses and time used as coffee agroforests; additionally, for some of these plots, elevation and geographical coordinates were recorded.

RESULTS AND DISCUSSION

Tzotzil Ethnoecology.—Ethnoecology was defined by Toledo (2000:1181–2) as a multidisciplinary theoretical and methodological approach "that explores how nature is perceived by human groups through a screen of beliefs and knowledge and how humans, in terms of images and symbols, use and/or manage natural resources" (see also Toledo 1999). This study reveals, describes and analyzes the ethnoecology of Tzotzil coffee producers of Polhó: their systems of management of natural resources that includes their cosmology, and local knowledge of biota, ecology, and pedology. Their ethnoecology incorporates structural, dynamic, relational, and utilitarian components, deriving from a wisdom that has been produced and reproduced through several generations.

This discussion covers some of the aspects considered by other authors to be pertinent in the context of traditional Tzotzil coffee growing systems in the stud-

TABLE 1.—Ethnopedological categories recognized by Tzotzil informants in Polhó, Chiapas.

	Texture	
Color	***cham-Lum*** 'clayey soil'	***chab-Lum*** 'silty soil'
ik' 'black'	***ik'al cham-Lum*** 'clayey black soil'	***ik'al chab-Lum*** 'silty black soil'
k'an 'yellow'	***k'anal cham-Lum*** 'yellow clayey soil'	***k'anal chab-Lum*** 'yellow silty soil'
tzoj 'red'	***tzajal cham-Lum*** 'red clayey soil' (unproductive land)	***tzajal chab-Lum*** 'red silty soil' (unproductive land)

ied area, and centers on the knowledge about the local ecological succession processes, vegetation, soils, climate, and part of the plant diversity that is managed as part of the floristic structure of coffee agroforests.

Ethnopedology.—Soils are fundamental for agricultural production processes. Thus, the ways in which Tzotzil farmers recognize and classify soil units enable them to establish adequate patterns of management of this resource. This ethnopedological knowledge may be transmitted across generations as well as across space. The first step involves describing and analyzing local ethnopedology, so that the patterns of management of soils may be better understood.

The Tzotzil informants recognized distinctive soil categories based on texture and color, indicating that they observe, manage, and identify the arable surface of the soil. This result confirms previous studies of Tzotzil ethnopedology (Cervantes-Trejo 1995; Pool-Novelo et al. 1992), and it demonstrates that the pedological classification elaborated by the Tzotzil is comparable to other ethnopedological systems worldwide that are based on the same criteria (Barrera-Bassols and Zinck 2000).

The primary lexeme for soil is ***Lum***. The recognized subclasses of soil are named by a secondary productive lexeme, which is formed by a lexeme for color, followed by a lexeme for texture, both of which are placed before the primary lexeme ***Lum***. Thus, Tzotzil ethnopedology has a hierarchical structure with a generalrank containing two inferior ranks, essentially generic and specific. The generic rank has different textures, suggesting different degrees of workability and humidity. The specific rank deals with color and fertility. As reported by Pool-Novelo et al. (1990), texture is the most relevant characteristic for Tzotzil ethnopedology, followed by color. In total six soil types were recorded, according to the Tzotzil ethnopedology of Polhó (Table 1).

Two classes of soils are recognized with respect to texture: "clayey" (***cham-Lum***) and "silty" (***chab-Lum***). They correspond to the soil categories used by the Tzotzil of San Juan Chamula (Chamula): "heavy soils" (***cham-Lum***) and "medium soils" (***cuc-Lum***), respectively. These soils are widespread in the Los Altos de Chiapas region (Cervantes-Trejo 1995). This difference in soil nomenclature is due to dialectal differences between the two communities. Cervantes-Trejo (1995) found in Chamula one additional soil texture category named "sandy or light soils" (***yi'al-Lum***), which was not reported in the coffee agroforests that were visited in Polhó. In this community, red, clayey soils are predominant, perhaps corresponding to the orthic luvisols previously reported to exist in the area (INEGI 1991). According to Pool-Novelo et al. (1990), the classifications of soil based on texture have a trend to designate different management conditions presented by these soils. These authors emphasize a relation between texture and humidity of the soil throughout the year, which together seem to define the timing for performing certain agricultural activities, the degree of difficulty of such activities, and the number of harvests that may be obtained during one year. Additionally, the texture of the soil determines the technology that must be employed, such as the specific characteristics of the hoes (Pool-Novelo et al. 1990).

Attending to color, the Tzotzil informants of Polhó recognize three soil classes based on color present in the studied area: ***ik'*** 'black', ***k'an*** 'yellow', and ***tzoj*** 'red'. The black color of the soils in the coffee agroforests is perhaps due to a high content of organic matter, which is derived from the decomposition of the usually thick layer of leaves that are mainly shed by the trees that provide shade, such as "*chalum*" or ***kok*** (*Inga* spp.), which are abundant in the coffee agroforests.

In Chamula, Cervantes-Trejo (1995) found the same color categories registered for Polhó, but she reports two additional types of soil: ***chacxik'*** 'gray' and ***zac*** 'white'. The gray soils develop from local soil management, by the addition of sheep manure to the ***k'anal cuc-Lum*** "yellow silty, or medium, soil" a characteristic of Tzotzil agropastoral systems with grazing sheep within karstic zones; cultivation helps give the soil a gray color (Cervantes-Trejo 1995). In contrast, the farmers in Polhó do not develop this agropastoral system and because of that the "gray" soil is absent in Polhó.

The ethnotaxonomy of soils of the Tzotzil, both in Polhó and in the other Maya communities of the Los Altos de Chiapas region, suggests a relationship between soil color and soil fertility (Pool-Novlo 1992; Cervantes-Trejo 1995). The Tzotzil lexemes used to name the color of soils, ***ik'*** 'black', ***k'an*** 'yellow', and ***tzoj*** 'red', are associated fundamentally with a decreasing level of fertility. Among the Tzotzil taxa of silty texture soils, ***chab-Lum***, the lexemes for color describe the degree of erosion of the black, top horizon of the soil, which when well developed is classified as ***ik'al chab-Lum***. As this top horizon's organic matter is washed away by the rain, however, new color lexemes are assigned by Tzotzil informants in accordance with the ethnopedological system. Through a process of surface erosion due to surface water run-off, these "silty black soils" are susceptible to being converted into ***k'anal cuc-Lum*** "yellow silty, or medium, soil," or further to ***tzajal cuc-Lum*** "red silty, or medium, soil." The perception of these processes associated with the dynamics of soil fertility is mirrored in the Tzotzil system for classification of soils and provides the framework for a connection of traditional techniques of soil management and soil conservation (Cervantes-Trejo 1995).

Techniques for soil conservation practiced in Polhó and in other communities of the coffee growing areas of the region range from the traditional activities of farming families such as tilling, addition of organic fertilizers (crop remains, manure, the hulls and flesh of coffee berries), the introduced techniques of "organic" agriculture, and the past traditional practices that were resuscitated by agricultural assistance workers of Majomut. These practices include: terrace building and installation of living fences or stones. All these techniques have been applied using local materials and germplasm and are part of the knowledge of the local people. Nevertheless, "innovative technology" for soil conservation, biological control of pests and diseases, and cultivation (control of shade) has been diffused both by the technical staff of Majomut and by local organic coffee promoters, and subsequently adopted in coffee agroforests. This process of innovation has taken place through the participation of local people, and the valorization of both the traditional knowledge and the resources available in the region's ecosystems. For example, in the composition of compost or manure several "organically-grown" materials have been used, including hay, banana leaves, herbs, and shrubs growing near the coffee agroforests. Likewise, for living fences use has been made of a varied spectrum of plant species growing in the *acahuales,* milpas, and home gardens of Tzotzil households.

Differences between ethnopedology in Chamula and Polhó may partly reflect dialect variations, such as the different names used for the same soil type (***cham-Lum*** and ***cuc-Lum***), although additional factors also help explain the ethnopedological differences observed. The geographic areas where Polhó and Chamula are located present different climatic, geological and physiographic characteristics that generate different soil types. Additionally, farmers of the two communities use different soil management techniques that change soil fertility, for instance, the "gray" soil produced only in Chamula. These differences are perceived by local farmers who encode them accordingly. Therefore, while the systems for classifying soils are structurally and taxonomically equivalent between the two communities, the soil types recognized and identified do exhibit some differences.

Tzotzil Conceptualization of Their Territory.—The Polhó region presents a considerable heterogeneity in its physiography and vegetation types. Moreover, the distribution of forest fragments and of surface water in the area are not homogeneous. All these factors contribute to a high diversity of environmental conditions and, consequently, a mosaic of suitable areas for agriculture recognized by Tzotzil informants. This knowledge is essential for coffee production, because this crop has ecophysiological constraints that limit the environmental range where it may be successfully grown and become productive (Willson 1999).

The Tzotzil of Polhó conceptualize the environmental complexity of their territory using the same categories as other Maya Tzotzil in the Los Altos de Chiapas region. They recognize and name two different landscapes in their territory: ***kisin osil*** 'warm farmland' and ***sikil osil*** 'cold farmland'. An additional intermediate or temperate physiographic zone is recognized by the Tzotzil but not formally named. Although these categories are used in general to name the areas in the Los Altos de Chiapas region with low and high elevation, respectively (Maffi 1999: 43), they possess ethnoecological significance since they establish a conceptual link between the physical and human geography and social organization (Maffi 1999:46). According to Luiza Maffi, these categories

> "do not simply designate physiographic features of the land such as climate or vegetation .... Rather, within the framework of what is commonly known as the Mesoamerican hot/cold dichotomy, these categories refer more specifically to the differential fertility and productivity of the

TABLE 2.—Distribution of the Tzotzil categories of the conceptualization of their territory in Polhó, Chiapas.

Tzotzil term	Sub-area	Average elevation (range) m asl (meters above sea level)	Land use/cover
kisin osil	1	1250 (1017–1500)	coffee fields, secondary vegetation
'warm farmland'	2	1150 (867–1584)	with tropical floristic elements (*acahuales*),
			corn fields
			sugarcane and banana planting
sikil osil	3	1600 (1418–1920)	corn fields
'cold farmland'			secondary vegetation with conifers
			coniferous forests
Unnamed	4	1400 (1339–1680)	corn fields
'temperate farmland'	5	1400 (1320–1540)	secondary vegetation with conifers and some coffee fields

land, by analogy with the concepts of the healthy vs. the diseased human body. The hot country and cold country categories should therefore be understood as ethnoecological concepts that inherently imply human relationship with the land." (Maffi 1999:41)

Within the context of coffee production, the territorial distinction made by the Tzotzil in the region allows them to order their space in terms of ecogeography and productivity. The ecological characteristics of any given area will determine what specialized crops may be grown there, together with maize, beans, squashes, chilies and other basic staples that historically characterize the diet of the Maya. Specialized crops such as coffee, citrus, bananas and other tropical fruits, and sugarcane are only cultivated in the ***kisin osil*** (Maffi 1999:45), although some producers may establish fields within the ***sikil osil***, either as an experiment or because they do not have available fields in the "hot country." Also, this territorial differentiation allows for the identification of differences in agricultural productivity, which in part is determined by the different climatic and altitudinal characteristics of these two named zones (Maffi 1999).

This ecogeographical and landscape heterogeneity, recognized by the Tzotzil, should differentiate zones with optimal conditions where coffee would be most productive. And indeed, farmers take these factors into account when they decide what use will be assigned to each available plot. The optimal area for coffee production appears to coincide with subareas 1 and 2 (Figure 1, Table 2), which have an average elevation of 1150–1250 masl, and where *acahuales* and coffee agroforests were found to be more densely distributed, together with maize, sugarcane and banana. These subareas were unambiguously classified by local farmers as "hot" country (Table 2).

Subarea 3, with an average elevation of 1600 masl, is perceived to be largely homogeneous and it is utilized for basic crops and coniferous forest maintenance. In contrast, subareas 4 and 5, with an elevation range between 1320 and 1680 masl and an average of 1400 masl, are recognized as more heterogeneous and they harbor portions of "hot," "cold," and "temperate" land (Table 2). Subareas 4 and 5 are used mainly for basic staple crops, with only a few coffee agroforests and a considerable extension of secondary vegetation dominated by conifers (Table 2). In general, the potential coffee growing areas in Polhó exhibit considerable extension and include elevations between 1000 and 1600 masl; the areas with high precipitation (above 2000 mm), evenly distributed along the year and with a well defined dry season; and the zones where the average yearly temperature is 18°C. Only a minor extension of the communal territory of Polhó is unfavorable for coffee cultivation. These lands correspond to subarea 3 and the southern parts of subareas 4 and 5 that are above 1600 masl (Figure 1). These marginal lands are reserved partly for forestry activities (gathering of firewood and medicinal plants) and partly for conservation purposes (communal forest reserves). These forest areas, together with their water sources, are considered sacred by the Tzotzil of Polhó, and special ceremonies take place there.

Tzotzil Categories of Ecological Succession.—Although the Tzotzil informants do not have a specific name for ecological succession, they recognize and identify stages of ecological succession by means of floristic and structural features intrinsic to the vegetation, such as vertical structure, and the diameter and tallness of the trees present in a site. These indicators of ecological succession are related to time elapsed after fields were released from cultivation of annual crops, such as maize, beans, squashes, chili, and peanut (González-Espinosa et al. 1994). In Polhó, they recognize different stages of ecological succession in the patches of vegetation previously used for rain-fed agriculture, that is, when fields are allowed to go into *descanso* 'fallow' (Figure 2).

The lands where grasses and other annual or perennial herbaceous species are abundant are named ***tz` i' leltik***. These are fields that were recently abandoned after a few cycles of planting/harvesting, because the cultivator perceived a decrease in soil fertility. The sites where the remains of previous crops (i.e., *rastrojo*, Spanish for maize stalks) are still noticeable and where shrub species such as ***k'ail*** (*Thitonia rotundiflora*) are abundant, are frequent in the area of Polhó and are named ***k'ajbenaltik*** or ***te'lal kájbe*** by Tzotzil informants. This difference of the nomenclature among informants is derived from dialectal variation in Tzotzil. In these two former cases the vertical structure of the vegetation is simple, lacks a tree stratum, and their cultivation ceased less than five years ago.

Succession stages that are more complex, both floristically and structurally, than those mentioned above are given the following names, in order of succession: ***unenaltik***, from ***unen*** 'tender', which refers to age and bole diameter of trees; ***toyolaltik***, from ***toyo*** 'tall', a mid-successional stage with taller structure; and ***abmaltik***, the mature or primary forests that have nearly vanished, according to local people. It may be safe to assume that the system for the classification of ecological succession of the Totzil in Polhó is equivalent to the classification used in the Los Altos de Chiapas region, based the recognition in the vegetation of a chronological sequence of changes, whose recognized stages are grassland, named ***tz` i' leltik***; shrubland, ***k'ajbenaltik***; early successional forest, ***unenaltik***; mid-successional forest, ***toyoaltik***; and, mature forest, ***abmaltik***.

In the intermediate successional stage, ***toyolaltik***, local people recognize sev-

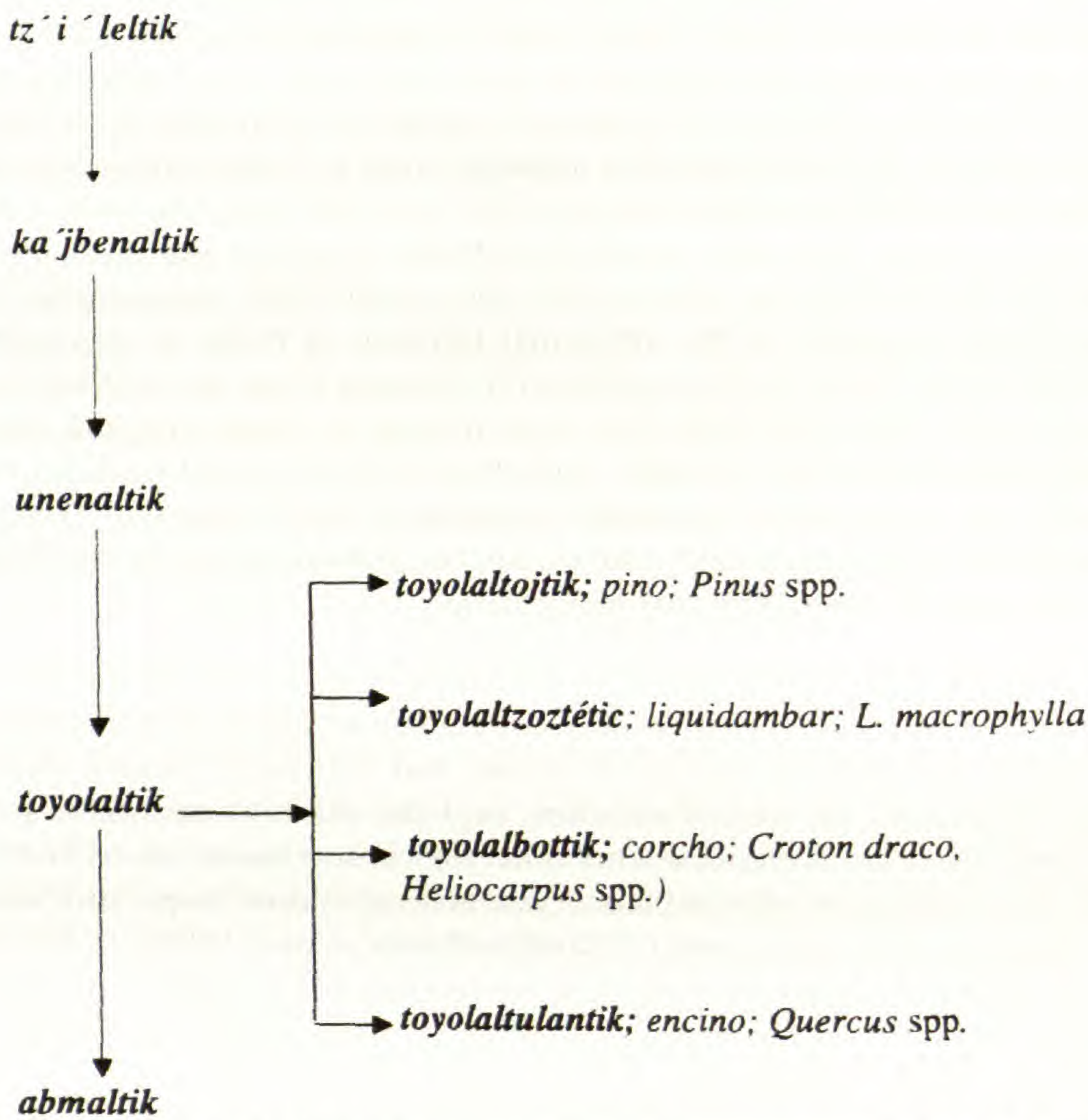

FIGURE 2.—Tzotzil words for the stages of ecological succession in Polhó, Chiapas.

eral plant communities of comparable age, which may be distinguished by the dominance or abundance of a given species of tree, whose name is included in the name for the successional stage. In such manner, mid-successional forests (***toyolaltik***) may be further classified as: ***toyolaltojtik,*** dominated by pines (***toj***); ***toyolaltzoztétik,*** where sweet-gum (***tzozté***) is abundant; ***toyolalbotik,*** dominated by *corcho* (***ch' ichi'bot***); and ***toyolaltulantik,*** dominated by oaks (***tulan***) (Figure 2).

Ultimately, indigenous cultivators use ecological succession as a way to restore soil fertility after a number of cycles of cultivation (Alcorn 1993). As one successional stage follows the next, nutrients are added to the soil, enabling the next period of cultivation in a sustainable system (Uhl and Jordan 1984). In addition, successional vegetation provides a variety of products used by local households (Toledo et al. 1995). The successional stages may also influence the energetic efficiency of coffee agroforest establishment, i.e., the balance between the needs of time investment (individual, family and paid labor), of technological resources (transportation and instruments) and of materials (plant germplasm). Such efficiency will be a function of the successional stage at which the coffee agroforest is established together with other factors, such as the distance and accessibility of the field, the size and age structure of the household, the head of household's financial resources, and other environmental components (topography and soil fertility). In theory, the cost of establishing a coffee agroforest will be greater if it is started in an early successional stage (***tz` i' leltik*** and ***k'ajbenaltik***) than if it begins in a more advanced stage (***unenaltik, toyolaltik*** or ***abmaltik***), other factors mentioned being similar and constant.

Because of the increase in population pressure and the land scarcity in the Los Altos de Chiapas region, the time during which fields are left to fallow has been shortened in recent years (Parra-Vázquez 1993a, 1993b). This intensification of land use causes a reduction in the number of fields (close to 5) and in the surface area for cultivation available per household (average of 2 ha). Hence, it has an adverse effect on agricultural productivity. Given this unfavorable scenario, the establishment of coffee agroforest systems and the utilization of ecologically sensitive "organic" techniques for coffee production appear to act as stabilizing factors, both for the economy of households and for the environmental sustainability of the zone.

Multiple-use Management of the Ecosystem and the Landscape by the Tzotzil.—Multiple-use strategies, as theorized by Toledo (1992), are based on the utilization of temporal and spatial diversity of resources and ecological processes. Tzotzil in Polhó maintain several types of land use and land cover (LU/LC) in order to take advantage of the varied natural resources characteristic of the ecosystem (Figure 3). This "multiple-use" strategy appears to be similar to those used for the management of natural resources by other traditional communities in the highlands and lowlands of the intertropical zone (Denevan et al. 1984; Dufour 1990; Marten 1986; Noble and Dirzo 1997; Posey and Baleé 1989; Toledo 1990; Toledo et al. 1994).

In terms of the diversity of strategies employed, 38 (76%) of the 50 producers interviewed maintained three or more types of LU/LC simultaneously (Figure 4). These are: rain-fed fields (for maize and beans); rustic coffee agroforests; fields in fallow; secondary vegetation in different successional stages; and to a lesser extent, grasslands for cattle, banana and sugarcane plantations. Only six (12%) of these producers maintained merely one type of LU/LC, i.e., are specialized; in those cases they produced only coffee in their own fields, and they shared the crop production and harvest, mainly maize, from fields belonging to close family members, especially their parents. Of the producers surveyed, 70% maintain three to five management units; these households, who practice diverse land management strategies, may be most able to balance productive diversity and energetic efficiency. Under the prevailing demographic, ecological and nutritional conditions, diversification is optimal.

Of the 278 fields mentioned by the 50 interviewed producers, 128 (46%) are devoted to the cultivation of coffee, 83 (30%) to rain-fed agriculture (maize and beans), 61 (22%) to ecological succession (fallow and secondary forest), and only 6 (2%) are used for other crops or productive activities including pineapple, banana, sugarcane and grazing land (Figure 5). In terms of total surface area, rain-fed agriculture is dominant, occupying over 50% of the territory (Bandeira et al. in press).

This result reveals two fundamental characteristics of traditional resource management and the microeconomic system studied: 1) the Tzotzil manage their

FIGURE 3.—Land use and land cover categories recognized and named by the Tzotzil in Polhó, Chiapas (Photograph by F.P. Bandeira). 1) ***chobtik,*** cornfield; 2) ***tz` i' leltik,*** land dominated by grasses and other annual or perennial herbaceous species; 3) ***k'ajbenaltik*** or ***te'lal kájbe,*** sites cleared the previous year where the shrub ***k'ail*** (*Thitonia rotundiflora*)—seen in the first plane—is abundant; 5) ***k'ajvetik/unenaltik,*** early successional forest with a canopy of *Inga* spp. where coffee is grown/secondary shrubland.

landscape using a multiple-use strategy (Toledo 1992) and 2) maize plays the central role in the economy of the peasants of Polhó, whereas coffee is exclusively a market product. The dynamics of the maize-coffee cultivation, and of the processes that are associated with it—i.e., deforestation for maize cultivation; management or clearing of the vegetation in order to allow the establishment of coffee; the management of ecological succession through the abandonment of cultivated field and through the establishment of diversified shaded coffee systems (reforestation)—must necessarily be the direct causes of the dynamics of the landscape itself.

Two aspects of the spatial pattern of distribution of the fields per household are important. First, the fields mentioned by the producers are not located within the same barrio and are not contiguous; that is, they are dispersed throughout the community's territory. Second, some of the dispersed fields lie outside the territorial limits of the community, within neighboring communities such as Tzajalukun, Yashgemel, Yabteklum and Yibeljoj, or even further away. Such a dispersed pattern of distribution of productive lands obliges some producers to walk one to five hours in order to reach their fields to do the necessary regular labor and to transport the harvest. It is probable that this considerable dispersion of fields is the result of several factors. The first of these is a sociocultural order related to the patterns of marriage and of inheritance; the second is the growing

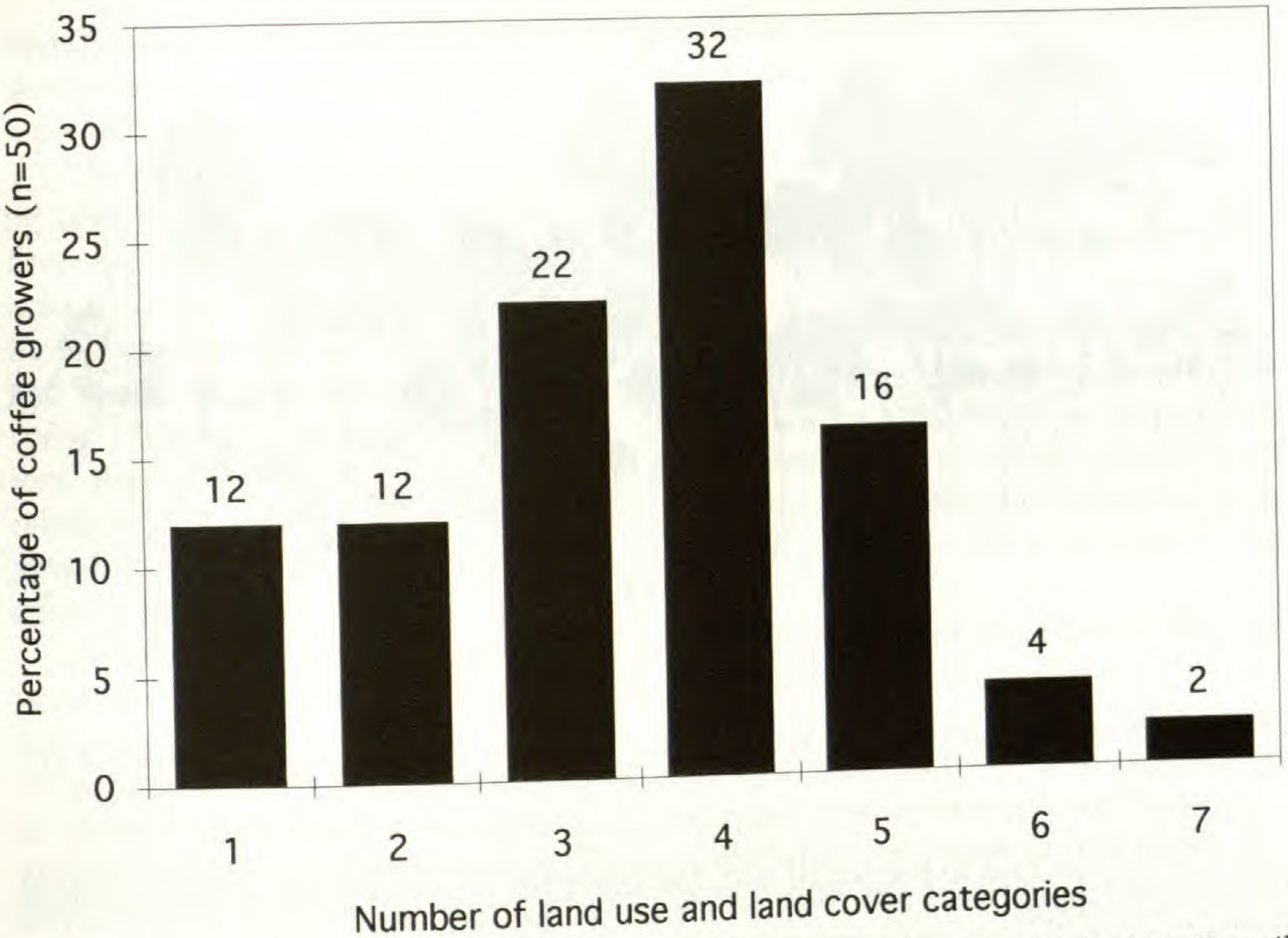

FIGURE 4.—Distribution of the number of land use and land cover maintained by Tzotzil coffee growers in Polhó, Chiapas.

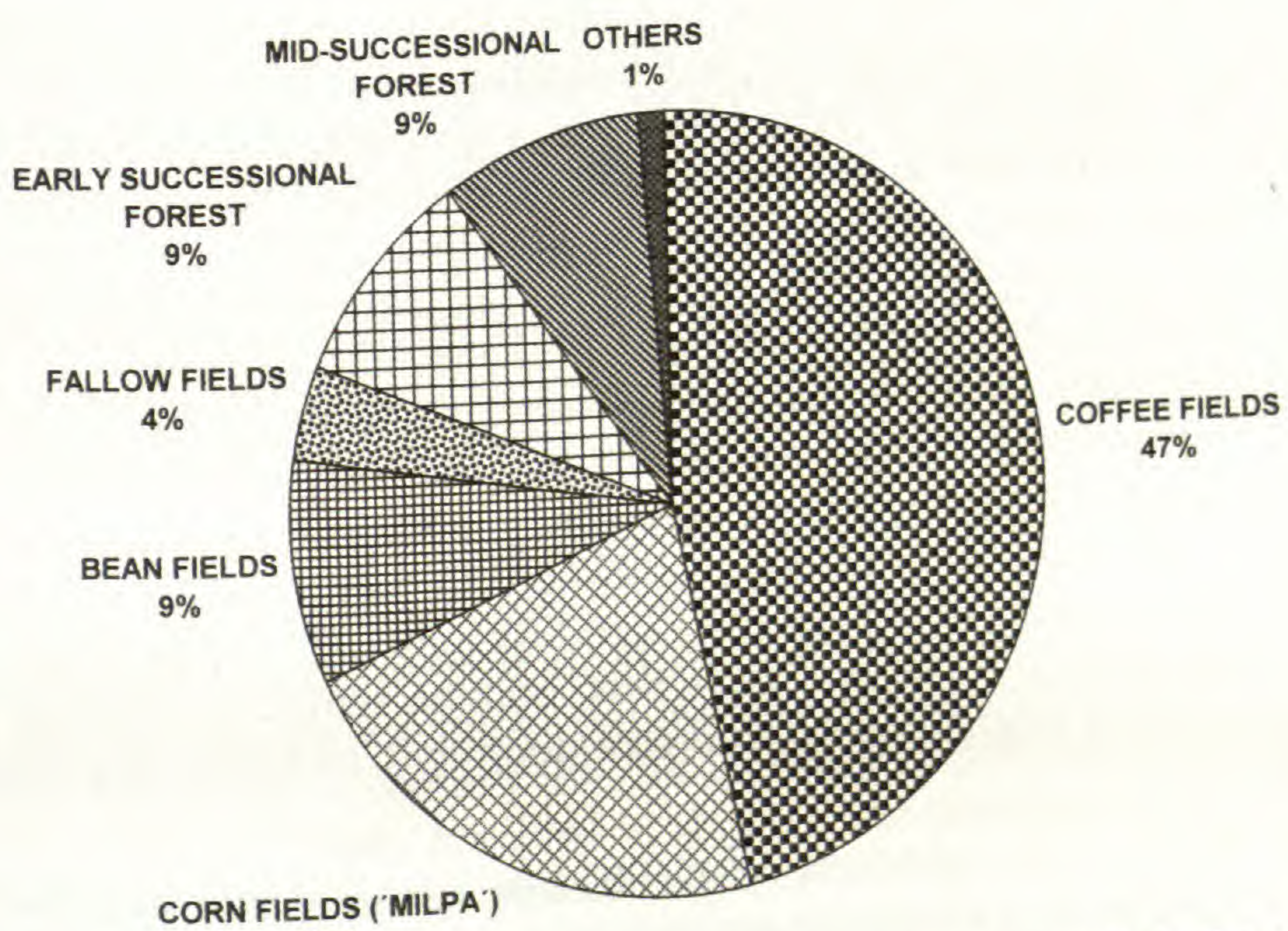

FIGURE 5.—Percentage of fields by category of land use/land cover in Polhó, Chiapas.

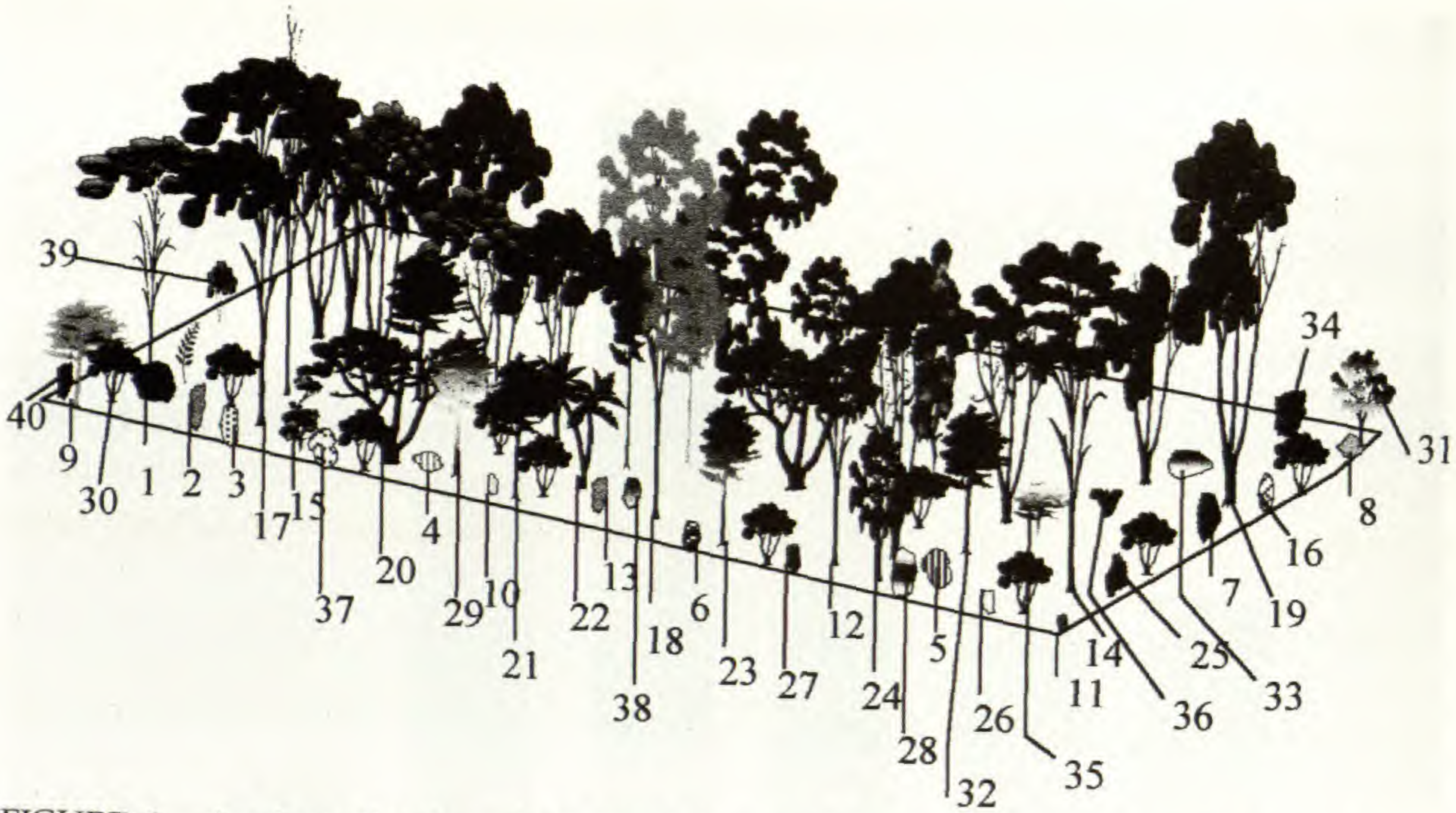

FIGURE 6.—A schematization of the vegetation profile of a one-hectare coffee field in Polhó, Chiapas.

scarcity of land, and to the social and demographic processes historically involved in this scarceness.

Some comments are needed regarding the sociocultural factors. The postmarital residence pattern of the Tzotzil is patrilocal and there is strict endogamy within the barrios of Chenalhó (Laughlin 1993). According to Laughlin (1969), in Chenalhó the elder sons leave the parental house when marrying and only inherit part of the land belonging to the household. The younger son remains in the parental house and receives a minor part of the father's inheritance. When they marry, daughters also inherit part of their father's land, for which the husband is made responsible. Land inheritance is, in other words, eminently partible. Thus, most of the producers interviewed had inherited some land from the father of their wife. But while some of these producers will reside in a different barrio or community, the fields tend to be some significant distance away from their houses. A similar spatial pattern has been describe for other Tzotzil communities, such as Chamula (Cervantes-Trejo 1995). Inevitably, this pattern of partible inheritance eventually results in the observed dispersion of agricultural fields.

The demographic factor mentioned above relates to the pressure on forested lands due to the population increase during the past forty years in the Los Altos de Chiapas region. This demographic surge has generated regional processes such as: migration, the expulsion of some members of the communities, and the colonization by the peasants of new lands (Parra-Vázquez 1993, 1994). Thus, some of the fields lying outside Polhó may have been bought, rented (a common practice in the region due to migration and land abandonment), or barely acquired legally by farmers.

The Tzotzil Rustic Coffee Agroforest.—The floristic survey made in a coffee field measuring one hectare provides a detailed picture of rustic coffee production in Polhó. Figure 6 represents a schematization of the vegetation profile of the surveyed coffee field, depicting some of the species that are present in these productive systems in the region, and in Table 3 are represented by their botanical aspects, their Tzotzil name, their use(s), and the plant part(s) used.

These rustic coffee agroforests are composed of a mixture of arboreal, shrubby, and herbaceous plant species, which are used as source of medicine, food, firewood, ceremonial effects, live fences, ornament, and other goods for the household. Some of these plant species belong to the original secondary vegetation; of these, most are fast growing pioneers species having short to medium life cycles, and a few are slow growing tolerant species having long life cycles. In addition, coffee agroforests acquire many plant species that are introduced by the cultivators, the most frequent origin of such germplasm being exchange among local relatives and neighbors, or it is carried from beyond the region either by occasional migrants or by governmental reforestation programs—as is the case of the *ciprés* (*Cupressus* sp.).

A total of 42 species in 35 genera and 23 families were recorded in the surveyed hectare of coffee agroforest (Table 3). Excluding the epiphytes, which were not collected, 18 of these species were of trees, 7 shrubs, 14 herbs, and 3 vines. According to management status as defined by Caballero (1996) and by Casas et al. (1998), these species are cultivated, tolerated and promoted, and their geographic origins are Mesoamerica, Europe, elsewhere in America and Asia. The similarity of these coffee agroforests in Polhó with the traditional Maya *solares* suggests the former to be an adaptation deriving from the introduction of coffee into the traditionally managed agroforests, a production system that can be traced to pre-Hispanic times.

This floristic survey—although not performed in other similar fields—and the field visits accompanied by the owners to 52 fields of coffee agroforests in Polhó, seem to disagree with Quezada's (1995) statement regarding the impact that was brought about by the transfer by INMECAFE of technological packages inspired in the "green revolution," which during the 1970s and 1980s resulted in the intensification of the rustic polycultural systems over 30% of the shaded coffee production areas of Mexico (Nestel 1995), including other indigenous zones, such as the Sierra Norte de Puebla region (Beaucage 1997), a process that seems to have been absent in Polhó.

Instead, in Polhó only 7 of the 52 visited coffee fields (13%) had a monospecific shade canopy—i.e., fields where a single tree species provides the shade needed for the growth of coffee, mostly those belonging to the genus *Inga*—while the remaining 45 (96%) had a tree stratum composed of two or more woody species.

The discrepancy with the statement of Quezada (1995) may, in part, be explained by the low number of fields visited by this author (n = 15) compared to the those recorded in the present study (n = 52). This difference in sample size, and the fact that the earlier author did not specify the spatial distribution of his study sites, allows us to suggest that his conclusions may not be generally representative of the processes involved in shaping the diversity of the tree canopy used for shading coffee in the area of Polhó.

In order to test these two contrasting hypotheses, it will be necessary to survey a representative number of coffee fields in the area to obtain a better under-

TABLE 3.—The species present in one hectare of rustic coffee plantations in Polhó, Chiapas, and related ethnobotanical information (Tzotzil name, plant part used, and use).

No.	Taxon	Life form	Common name	Tzotzil name	Used part[a]	Use(s)[b]
	Amaranthaceae					
1	*Iresine celosia* L.	herb	—	***tzajal kam vomol***	1	2
	Apiaceae					
2	*Eryngium* sp.	herb	*cilantro*	***kulantu***	1	1
	Araceae					
3	*Xanthosoma* sp.*	herb	*malanga*	***is-ak' max***	1, 2	1, 1
	Asteraceae					
4	*Bidens pilosa* L.	herb	—	***matas/tz'ekuntul***	5	1
5	*Sonchus oleraceus* L.	herb	—	***uskun-te`***	5	1
6	*Tagetes erecta* L.	shrub	*flor-de-muerto*	***nichim anima'***	5	2, 7
7	*Tithonia rotundifolia* (Miller) Blake.	shrub	—	***k'ail***	1	2, 8
8	*Tridax* sp.	herb	—	***tzepenté***	5	1
9	*Vernonia deppeana* Less.	tree	—	***sitit***	3	3
	Commelinaceae					
10	*Commelina* sp.	vine	*comelina*	***tz`emeni`***	5	6, 7
	Cucurbitaceae					
11	*Sechium edule* (Jacq.) Swartz*	vine	*chayote*	***ch'um-te`***	6, 2	1
	Cupressaceae					
12	*Cupressus* sp.*	tree	*ciprés*	***nukul pat***	—	—
	Chenopodiaceae					
13	*Chenopodium ambrosioides* L.	herb	*epazote*	***koko' on***	1	1, 2
	Euphorbiaceae					
14	*Croton draco* Schlecht	tree	*palo-de-sangre*	***ch'ich'bot***	1, 6	2, 3, 4
15	*Euphorbia pulcherrima* Willd. Ex Klotzch*	shrub	*nochebuena*	***sera nichim***	5	5
	Fabaceae					
16	*Phaseolus vulgaris* L.*	vine	*frijol*	***chenek'***	6	1
	Icacinaceae					
17	*Oecopetalum mexicanum* Greenm. & Thomps.*	tree	—	***kakav te`***	6	1,7
	Lauraceae					
18	*Persea americana* Mill.*	tree	*aguacata*	***on***	6	1, 4
19	*Persea schiedeana* Nees*	tree	*chinino*	***ib***	6	1, 4

TABLE 3.—(continued)

No.	Taxon	Life form	Common name	Tzotzil name	Used part[a]	Use (s)[b]
	Mimosaceae					
20	*Inga* cf. *leptoloba* Schlecht.	tree	*caspirol*	***tz'erel***	6, 7	1, 3, 4
21	*Inga vera* Willd.	tree	*paterna*	***chalon***	6, 7	1, 3, 4
22	*Inga xalapensis* Benth.	tree	—	***chalon***	6, 7	1, 3, 4
	Musaceae					
23	*Musa acuminata* × *M. balbisiana**	tall herb	*plátano guineo*	***kokon lo `bol***	4, 6	1, 6
			plátano rojo	***tzajal lo `bol***	4, 6	1, 6
			plátano manzanillo	***mántzana lo `bol***	4, 6	1, 6
	Myrtaceae					
24	*Eucalyptus* sp.*	tree	*dolar*	—	5	5
25	*Psidium guajava* L.*	tree	*guayaba*	***potov***	1, 6	1, 2
	Phytolaccaceae					
26	*Petiveria alliacea* L.	shrub	—	***poite`***	1	2
	Piperaceae					
27	*Piper sanctum* (Miquel) Schlecht.	shrub	*hierba santa*	***mumun***	1, 4	1
	Poaceae					
28	*Cymbopogon citratus* (DC.) Stapf.*	herb	*zacate-limón*	—	1	2
29	*Saccharum officinarum* L.*	herb	*caña-de-azucar*	***vale`***	4	1
	Rosaceae					
30	*Eriobotrya japonica* Lindl.*	tree	*níspero*	***nixpero***	6	1
31	*Prunus persica* (L.) Stokes*	tree	*durazno*	***turasno***	6	1
32	*Prunus serotina* Ehrh.	tree	*ceresa*	***chix te`***	6	1
33	*Pyrus communis* L.*	tree	*pera*	—	6	1
	Rubiaceae					
34	*Coffea arabica* L. var. *arabica**	shrub	*cafè arabigo*	***kajve***	6	1
	Rutaceae					
35	*Citrus aurantifolia* Osbeck*	tree	*limón*	***eromunix***	6	1
36	*Citrus sinensis* (L.) Osbeck*	tree	*naranja*	***narinxa***	1, 6	1

TABLE 3.—(continued)

No.	Taxon	Life form	Common name	Tzotzil name	Used part[a]	Use(s)[b]
	Solanaceae					
37	*Capsicum* sp.	herb	*chile*	***mukta'ich***	6	1
38	*Nicotiana tabacum* L.*	herb	*tabaco*	***moy***	1	2
39	*Physalis* sp.	herb	—	***murusin itá***	1	1
40	*Solanum americanum* Miller	herb	*hierba mora*	***kokonxo`***	1	1
41	*Solanum* sp.*	tree	*tomate de árbol*	***caranato chichol***	6	1
	Verbenaceae					
42	*Lantana* cf. *camara* L.	shrub	*té chino*	***chi'il vet***	1	2

Numbers in first column refer to species represented in Figure 6.
* Identified *in situ* by the authors.
[a] Used plant part key: 1) leaves; 2) roots; 3) trunk; 4) stem; 5) whole plant; 6) fruits; 7) branches.
[b] Use key: 1) food; 2) medicine; 3) firewood; 4) shade; 5) ornamental; 6) soil protection; 7) ritual; 8) fertilizer.

standing of the floristic composition and structure of the tree canopy used as shade for coffee in Polhó. However, two important remarks may be made at this point: first, in Polhó, there is not a single unshaded coffee planting. This suggests that the programs aimed at the elimination of shade in coffee plantations, carried on by INMECAFE in the state of Chiapas, have been unsuccessful in the area of Polhó. The second observation which supports the rejection of the hypothesis of "modernization" of coffee production systems in Polhó is the preference by local coffee producers for unimproved coffee variants they inherited from their progenitors: the *tipica* or *criolla* (*Coffea arabica* var. *arabica*) and the *bourbon* (*Coffea arabica* var. *bourbon*). This resistance of local coffee producers to the adoption of "technology packages" that promote the elimination of shade for coffee, the utilization of industrial inputs such as fertilizers and agrochemicals, and the adoption of high-yielding varieties—which hampered the production of coffee in Mexico during the 1970s and 1980s—largely shielded the area from its effects. Instead, such modernizing efforts were more successful in zones where private property prevailed and coffee production was in the hands of specialized middlemen or major entrepreneurs with substantial capital (Nolasco 1985).

The Tzotzil Management of Ecological Succession: the Design and Construction of Coffee Agroforests.—As has been reported for other areas (Perfecto et al. 1996; Rice 1997), Polhó rustic coffee agroforests are most commonly established on previously cultivated fields and to a lesser extent on secondary growth vegetation. This is demonstrated by the management history of 52 coffee-growing parcels in Polhó: 33 (63%) were established on fields formerly used for other crops such as ***chobtik*** 'corn fields', ***vale'tik*** 'sugarcane fields', or ***lo`boltik*** 'banana fields'; 18 (35%) were established on secondary growth (*acahuales*), and 1 (2%) was established on mixed use land (crops and *acahual*) (Figure 7). These data provide strong evidence that the evolutionary trend in landscape management in the Polhó area has revolved around substitution of parcels planted with annual crops and other crops (sugarcane and bananas) with diversified shaded coffee-growing systems. Figure 8 shows how local inhabitants perceive the temporal relationships of vegetation types (that is, successional stages).

The main activities that are developed by coffee producers to create the coffee agroforest are: 1) the clearing of the understory of a patch of mature forest and the planting of coffee under the tree canopy and 2) the establishment and maintenance of the tree and shrub strata by means of cultivation, tolerance, promotion, and rejection of individuals and populations of plant species based on their "emically" perceived worth for the productive system.

Our preliminary observations of Tzotzil practices for the establishment of rustic polycultural systems suggest that the design and construction of coffee agroforests—and perhaps in other coffee producing indigenous zones of Mexico as well—is the outcome of a complex process of management of the floristic structure. By exerting some control over species composition, tree density, and number of plant species per unit of area, farmers influence the survival rate of permanent, tolerant, pioneer plant species in two different ecological systems: 1) patches of mature forest; 2) lands where formerly rain-fed agriculture was practiced (in the cycle *milpa-acahual*) or where there were plantations of banana and sugarcane.

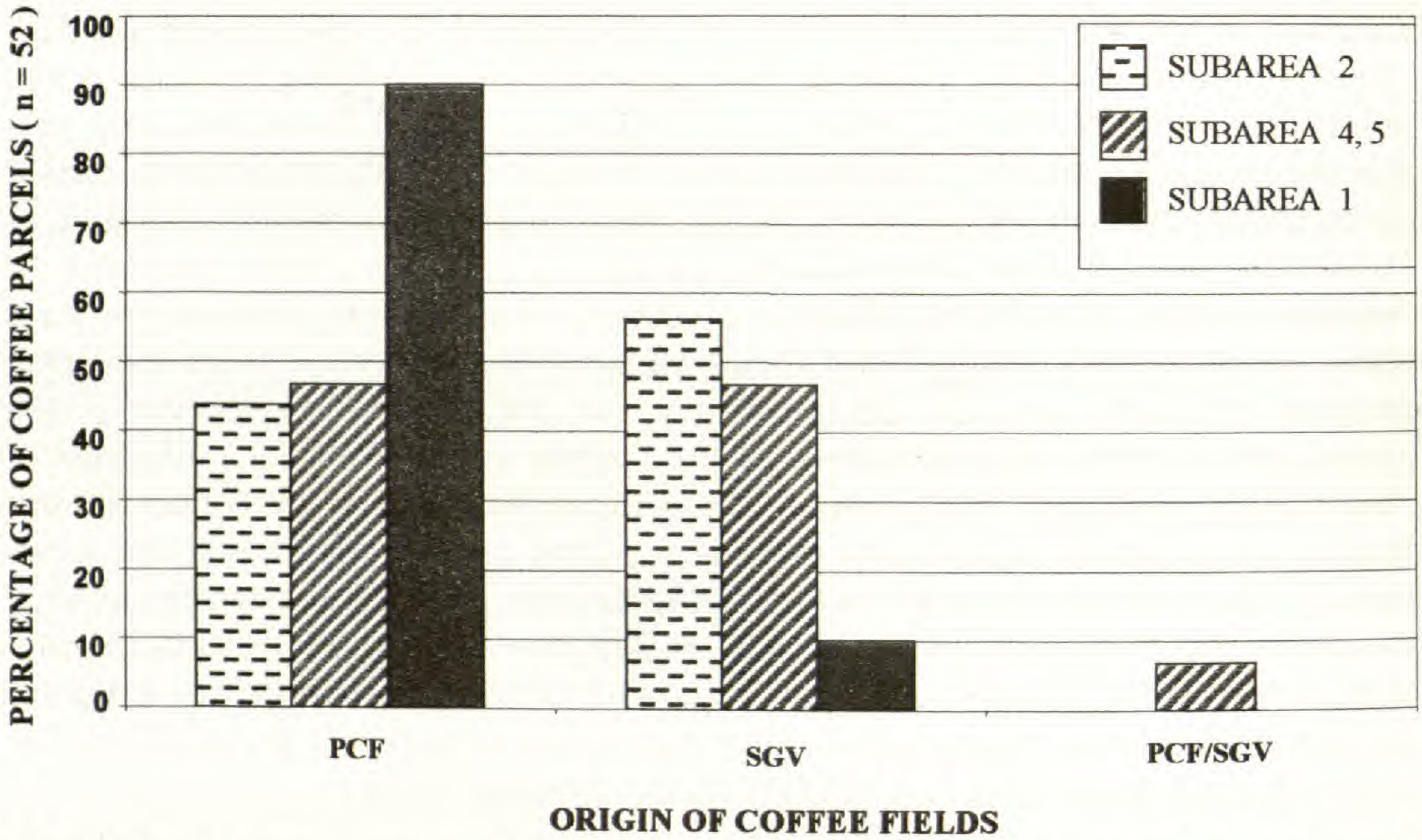

FIGURE 7.—Origin of coffee fields in Polhó, Chiapas. PCF: Previously Cultivated Fields; SCV: Secondary Growth Vegetation

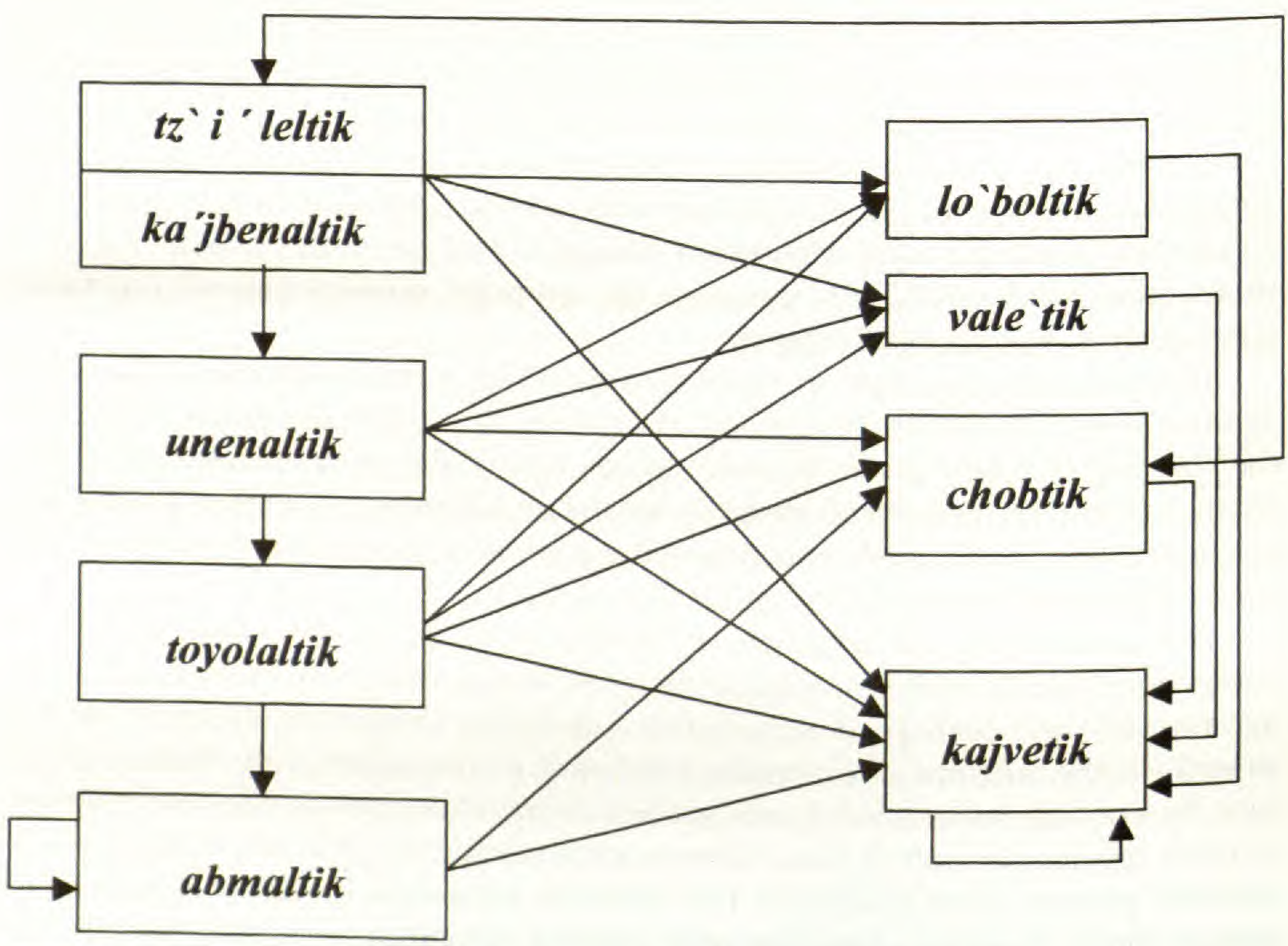

FIGURE 8.—Tzotzil perception of landscape dynamics in Polhó, Chiapas.

When establishing a coffee agroforest, the farmer, although in a not completely directed and controlled way, aims at obtaining a desired floristic composition or, in cases when trees are already growing on a plot, at the use and modification of the existing floristic structure.

In this section we describe a case when a farmer establishes a coffee agroforest on fields previously used for rain-fed milpas or other annual crops, which is the dominant situation in Polhó (Figure 8). In such cases, some of the events that will decide which floristic structure will result in the rustic coffee agroforests seem partially random—colonization and seed immigration—and may either be taken advantage of or remain unperceived by the farmers. Alternatively, the process may be managed directly by the farmer. These latter volitional factors imply the management of individuals, plants, and populations by means of cultivation of domesticated species; promotion of fast-growing, nitrogen-fixing wood and fruit-producing wild species, which is accomplished by the dispersion into the new coffee agroforests of seeds and propagules from other local ecosystems, such as milpas, fields in fallow, secondary and mature vegetation; tolerance and protection of species considered to be useful that were previously present in the new field; and the elimination of some individuals belonging to unwanted tree, shrub, pioneer species.

Through these management activities, the farmer appears to be setting forth a process which is analogous to that of natural ecological succession. These activities will resemble a sequence of events that would occur without human intervention, that is, that would be determined purely by stochastic and historical-ecological processes, such as: facilitation and inhibition, colonization and immigration of seeds ("seed-rain") and other propagules, competition, and others (McCook 1994). The activities carried on by local farmers for establishing and maintaining the tree-shrub canopy of a coffee agroforest suggests these farmers have ample ecological knowledge and are thus able to manage succession to their advantage.

The adoption of coffee by Maya farmers originated in and was adapted to the model of agroforestry systems known and managed by these people before the Spanish Conquest. Present-day Maya farmers also inherited some of the knowledge of plants and ecological processes which is critical for the construction of such agroforestsfrom their forbears. Some species of legume trees, such as *Inga* spp., have been utilized in agroforests since pre-Hispanic times, when they were interplanted with cacao (Gómez-Pompa 1987). This accounts for their widespread utilization in present-day rustic coffee agroforests.

The successful establishment of a coffee production system requires knowledge of the biology of certain key species, such as those of the genus *Inga*. This genus has many species in Mexico. Most are fast-growing small trees, and when cultivated have a dense, widespread canopy, some species being deciduous and shedding large amounts of leaf biomass. Many *Inga* species, moreover, are able to fix nitrogen in the soil. Species of *Inga* grow in the lower canopy of medium and tall evergreen tropical forests and as pioneer species in certain types of secondary vegetation. Such biological and ecological characteristics of species of *Inga* are recognized and utilized by Tzotzil farmers, who are conscious of several fundamental functions of these trees for the process of establishing and maintaining of coffee agroforests: 1) they provide shade to coffee shrubs during the early years of production when other trees in the field have not yet completed their development; 2) they provide organic matter to the soil in form of leaf mold; 3) they are adequate for shading coffee, but at the same time are easy to prune; 4) they protect the soil from the impact of rainfall; 5) the shade and mulch from *Inga* contributes to checking the growth of invasive species that enter into competition with the coffee shrubs and other useful saplings. Because of these characteristics, species of *Inga* seem to be biological models, or "archetypes" of shade trees for coffee agroforests during the initial stage of their establishment, and are amply used by local people, who recognize and protect the saplings of *Inga* spp.—as well as of other trees—cultivating and promoting them by dispersing their seeds within the fields. Acting in such manner, farmers probably accelerate, foment, and direct, in part, the ecological succession of the managed vegetation patches. All this is accomplished by means of the management techniques described above, which induce processes that, at different rates, are also occurring in natural ecological succession, such as: the increase in survival rates of desired species, the decrease of the population numbers of invasive herbaceous species (grasses and sedges), the increase of organic matter content of the soil and the improvement of its physical structure, the favoring of the establishment of plants with strict nutrient requirements, and so on. In addition, by planting *Inga* spp. and of other fast growing trees, farmers, intentionally or not, favor the perching of bats and birds, which act as seed-dispersal agents for potentially useful species.

In conclusion, the perception, naming and identification of stages, and the understanding of the process of ecological succession of the vegetation by Tzotzil farmers in Polhó are all relevant for understanding how this ethnic group manages natural resources, in particular with respect to coffee production systems. The design and establishment by Tzotzil farmers in Polhó of a rustic coffee agroforest, which requires the use of adequate production and natural resource conservation technologies, is a process that has its ultimate foundations in the knowledge owned by the cultivators about the local diversity of plants and of their uses, the ecological processes that are potentially useful (ecological succession), and the natural resources (soils) and environmental factors (climate, topography) that may impose constraints on the production system. A large part of this knowledge is transmitted from fathers to sons and is exchanged among near and allied relatives of large kindred. Additional information is acquired in practice during the process of management itself, or is supplied by the technical staff of Majomut through training and technology transfer programs.

NOTES

[1] Because of the dispersed distribution pattern of fields, the boundaries of each community are almost impossible to define; as a consequence, study subareas were defined following physiographic criteria, such as basin limits, watercourses, and, in a few cases, structural disjunctions (faults).

[2] The "organic coffee promoter" originated from the process of merging with the European organic product market, after Majomut was granted certification by *Naturland*. The organic coffee promoter is a member of the community or barrio who is elected in a cooperative

meeting. His functions are to promote and diffuse technical information concerning the methods of organic cultivation among members of Majomut. The technical staff of Majomut, composed of agronomy technicians and engineers, is in charge of delivering training courses and of supervising the promoters' work.

ACKNOWLEDGMENTS

We wish to thank the technical staff of the Unión de Ejidos y Comunidades del Beneficio Majomut for their valuable support during the fieldwork; in particular, to its president, the technicians and engineers V. Pérez Grovas, E. Cervantes-Trejo, Alberto, Eliseo, Walter, Gilberto, Fernando and Juan. We also thank the organic coffee promoters of Polhó for their attentions while staying in the community and their willingness to share their knowledge, and finally, thanks are due to Mónica for her support and stimulus during the whole time that we visited the state of Chiapas. This research was made possible thanks to a scholarship granted by the Secretaría de Relaciones Exteriores de México (1997), support given by the Unión de Ejidos y Comunidades del Beneficio Majomut (1997), and the Universidade Estadual de Feira de Santana, Brazil (1998–2000) through the program of Academic Improvement of Technicians and Researchers. We are also grateful to Dr. William Baleé for his suggestions and revision of the English and to Editor Dr. Naomi Miller of the *Journal of Ethnobiology* for offering many constructive suggestions for improving this paper. I would like to thank Jorge Saldívar and Carlos Wallace who helped in the computer assisted processing of the illustrations.

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Journal of Ethnobiology 22(2): 273–284 Winter 2002

TRADITIONAL TENURE SYSTEMS REGULATING FOREST PRODUCT EXTRACTION AND USE BY THE ANTANOSY OF MADAGASCAR

LINDA M. LYON [a] and LINDA H. HARDESTY [b]

[a] *Department of Biology, Frostburg State University, Frostburg, MD 21532*
llyon@frostburg.edu

[b] *Department of Natural Resource Sciences, P.O. Box 646410, Washington State University, Pullman, WA 99164-6410*
lhardest@wsu.edu

ABSTRACT.—The Antanosy of southeastern Madagascar rely on forest products to meet their daily subsistence needs; the forest itself provides land for agricultural expansion (Lyon 1999). An informal local land tenure system regulates the collection and ownership of forest products. Local forest management is critical to the management and conservation of the forest. Although the particular resource concerned determines the restrictions placed on land use, systems exist to regulate most aspects of forest use. This research investigated particular aspects of forest use and the local use of a *dina* (or community-based contract). The Antanosy use dinas to clarify and define individual and community responsibilities including particular aspects of land tenure. Such agreements exist to give the community control over their own use of forest products such as wood harvested for construction purposes, uncultivated fruit, and water distribution for rice paddy irrigation. This paper explains the Antanosy tenure system for forest use and the implications for community-based conservation projects.

Key words: land tenure, *dina,* Madagascar, Antanosy, community.

RESUMEN.—Los Antanosi del sudeste de Madagascar dependen de los productos forestales para cubrir sus necesidades cotidianas de subsistencia; el bosque además proporciona terreno para la expansión agrícola (Lyon 1999). Un sistema informal local de uso del territorio regula la recolección y propiedad de los productos forestales. El manejo forestal local es crítico para la gestión y conservación del bosque. Aunque cada producto forestal en particular determina las restricciones impuestas al uso del terreno, existen sistemas de regulación para la mayoría de los aspectos del uso del bosque. Este estudio investiga aspectos particulares del manejo del bosque y el uso local de una *dina* (o contrato basado en la comunidad). Los Antanosi utilizan las dinas para definir y clarificar responsabilidades individuales y comunitarias y algunos aspectos del uso del terreno. Este tipo de acuerdos existen para conferir a la comunidad un control sobre su propia explotación de los productos forestales tales como madera talada para construcción, frutos silvestres, y distribución del agua para la irrigación de campos de arroz inundados. Este artículo explica el sistema de tenencia de los Antanosi para la explotación del bosque y sus implicaciones para proyectos de conservación basados en la comunidad.

RÉSUMÉ.—Les Antanosy du Sud Est de Madagascar tirent la plus grande partie de leur subsistance quotidienne de la forêt qui fournit également la terre pour l'expansion agricole (Lyon 1999). Un régime foncier local officieux régit la cueillette et la propriété des produits de la forêt. La gestion forestière locale est essentielle à l'aménagement et à la conservation de la forêt. Bien que les ressources particulières déterminent les restrictions imposées sur l'utilisation des terres, des systèmes en place régissent la majorité des aspects de l'exploitation de la forêt. Ce projet a étudié des aspects particuliers de l'exploitation de la forêt et l'utilisation locale d'une *dina* (ou contrat communautaire). Les Antanosy ont recours aux dinas pour clarifier et définir les responsabilités individuelles et communautaires et certains aspects du régime foncier. De tels accords permettent à la communauté de contrôler leur propre exploitation des produits forestiers, comme la coupure des arbres pour le bois de construction, la cueillette des fruits sauvages, et la distribution de l'eau pour l'irrigation du riz paddy. Cet article explique le système foncier des Antanosy pour l'exploitation de la forêt et ses conséquences pour les projets communitaires de conservation.

INTRODUCTION

In many traditional societies, community-based, informal land tenure[1] defines social relationships between people and their property at a level of land management that often overrides government control of the area (Lynch and Alcorn 1994). Indigenous cultures often establish tenure systems to regulate natural resource use and prevent overuse of a resource by any one person, and satisfy human needs (Glaesl 2000). Tenure can determine who is allowed to use a particular resource and the circumstances surrounding that use. It is through these relationships that land-use rules are developed (Lynch and Alcorn 1994).

Understanding relationships among members of an indigenous culture is crucial in the design of successful conservation or development projects. Experience reveals that many project planners fail to consider this. Conservation and development projects in many "third world" countries are often based on community management systems. Integrated conservation and development projects (ICDP) in the early 1990s are examples of projects that were designed for first world conditions. Intended to unite a village or set of villages at a community level, these projects failed in areas where strong kinship ties and conflicting local land tenure systems existed. The point here is not so much that ICDP projects should have been managed at a family level, but that a thorough investigation of the region's land tenure systems should have been part of the project design.

This paper will discuss the Antanosy's land tenure system in terms of how it is used to manage the collection and ownership of forest products. Given this indigenously designed and managed system for regulating forest products, we argue that only by designing a conservation system around a local management plan will forest resource conservation plans be successful.

METHODS

Study Area.—The eastern region of Madagascar covers just under half the island, extending westwards from the east coast to cover the central highlands. This area is thought to originally have been completely forested, but much of the forest has now been replaced by a mosaic of cultivation and secondary rain forest (Harcourt and Thornback 1990). Field research was conducted from 1995–1998 in the Tsitongambarika classified forest, Parcel I (24°50′ S, 46°53′ E), a government established mixed secondary and dense rain forest that is part of the coastal strip of southeastern Madagascar (Direction des Eaux et Forêts and Conservation International 1993). The forest is actually divided into two connected sections, the more southern Parcel I and Parcel II. Parcel I was created in 1965 with 9,530 ha reserved to act as a buffer for the larger and more unique area of the now named Andohahela National Park. In 1970, the Malagasy Ministry of the Environment enlarged the reserve by establishing Parcel II which included another 38,930 ha to the north, as they felt that Parcel I was not an adequate buffer for the large and heavily visited forests of Andohahela (Direction des Eaux et Forêts and Conservation International 1993). The region where this research was conducted was under local jurisdiction by the people belonging to the Fokontany of Tamboro. (A *fokontany* is the lowest ranking administrative level recognized by the Malagasy government and is usually made up of several villages or approximately 1,000 people.) The Fokontany of Tamboro consists of seven villages that rely almost solely upon the Tsitongambarika for their forest product needs. Villages are between one and four kilometers from one another and three to five kilometers from the forested region of Tsitongambarika.

The Antanosy constitute the majority of the inhabitants of the southeastern region of Madagascar, which encompasses the Tsitongambarika Classified Forest. Today, like other ethnic groups of the south, they are thought to be among the country's poorest people, living on what they find in the forest or eking out a meager existence with irrigated paddy rice (*Oryza sativa* L.) (Figure 1) and cattle (*Bos indicus*).

The ancestors of the Antanosy migrated from northern Madagascar to the area approximately 150–200 years ago (Mittermeier et al. 1994). The modern Antanosy are mixed with others who passed through the area. The first were from the Zafiraminia Dynasty who arrived in northern Madagascar from the Persian Gulf or Indian subcontinent (Goodman and Patterson 1997) and crossed the island to the Antanosy region. The people of the dynasty declared themselves princes and kings upon their arrival and came with advanced innovations. Later the French gained a foothold in Madagascar during their voyages to the East Indies, as did the Portuguese, who used the area as a stopover en route to India. The Merina people of the high plateau of Madagascar came from a third direction and stayed in the Antanosy region for several years during their nineteenth-century expansion period (Goodman and Patterson 1997).

The region encompassed by the Fokontany of Tamboro is approximately 4 km from east to west and 2 km from north to south. The seven villages that make up the Fokontany of Tamboro are accessible only by footpath. Each village is approximately 2–3 km from one edge of the protected forest. Although Tamboro once had a dirt road running through it that could be accessed by vehicle, the road has fallen into disrepair and is no longer used. Today a vehicle-accessible dirt road exists to the west of Tamboro. Most villagers use this road when relying on public transport or for transport of their agricultural products to the regional market of Fort Dauphin.

FIGURE 1.—Irrigated paddy rice near the Fokontany of Tamboro, Madagascar. Photograph by Linda Lyon.

Population Census.—Prior to the onset of fieldwork a meeting was held with village leaders to acquire permission to conduct interviews. It was explained to them that the study was to help the first author complete her academic degree and part of her service as a Peace Corps Volunteer in Tamboro. Also, since the first author had lived in Tamboro for approximately eight months as a Peace Corps volunteer before beginning the survey, villagers knew her and most had accepted her into their homes. She had become a friend to many village women through an earlier gardening cooperative she helped them organize. The second author was introduced to the Tamboro community before the first phase of the study to aid in research design. The second author was essential for the data analysis and the writing of the final manuscript.

This study began with a census of all villages in Tamboro to define the sample frame for subsequent data collection. A total of 304 households were found within Tamboro in August, 1995. An acceptable sample size was calculated from the total number of households in Tamboro using the formula described by Krejcie and Morgan (1970), and 170 interviews were conducted.

The household (also referred to as a family in this study) is based on paternal kin relationships of marriage, relatives sharing the same house or sharing common food preparation or consumption (Durbin 1990). The household usually remains economically independent from a larger family group yet share in the larger family's agricultural production. This larger family group often makes up one hamlet and several hamlets are found within each village.

Interviews.—Interview questions were open-ended, allowing informants an opportunity to develop their responses into a conversation. The questionnaire evolved throughout the project, as notes from interviews were transcribed and new themes or ideas developed. New questions were periodically added as topics were identified, and other questions were removed from the questionnaire when they generated a uniform response.

Interviews were conducted from September through mid-November, 1995. Interview times were varied throughout the week and the questions asked did not pertain solely to the current season. Interviews varied in length from forty-five minutes to two hours depending on the detail of the responses. Interview participants consisted of anyone over the age of fifteen who was part of the household unit and willing to respond to questions during the time of the interview. No one declined to be interviewed. Although most interviews took place in villagers' homes, separate interviews with women were sometimes arranged at a time or place less subject to domination or interruptions by men. Other interviews included key informants such as village elders, traditional healers, and school-teachers. These informants were helpful in clarifying villagers' responses to particular questions and they usually had insightful viewpoints due in part to their longevity in the region and participation in village affairs.

Three years of participant observation in Tamboro provided additional data and clarified information generated in interviews. Observations of villagers' activities took place throughout the study, during and after interviews. Throughout this time, the first author participated in many activities, including planting and harvesting rice and manioc, collecting firewood, and gathering wild foods, as well as the social activities within Tamboro. Her inclusion in day-to-day activities gave her insight into local uses of natural resources and agricultural production that may not have been gained through interviews alone.

Coding and Analyzing Data.—Natural resource use by villagers was not quantified. Such data would have been relevant to our objectives but were beyond the scope of the project. Instead this issue was defined by scarcity relative to the previous 10 years and to current needs. Interview results were organized by household, date of interview, and gender of the interviewee. No other demographic information about the interviewees was collected. Information that was not recorded during interviews was added to field notes shortly afterward. Grounded Theory (Glaser 1978), a type of qualitative analysis, was used to analyze the data collected from the interviews. The grounding of a theory is achieved when questions are rephrased during an interview and responses are compared with responses from other interviews until there is no doubt about the accuracy of the theory created by the responses. At this point responses are then saturated as described by Glaser and Strauss (1967) and Glaser (1978). Categories of data are then created and analyzed to explore relationships.

RESULTS

Dinas and the Antanosy Land Tenure System.—In Madagascar, all villagers living in a fokontany are under the jurisdiction of a local government. Communities create and enforce *dinas*, which are written rules that govern how people live within the community. Dinas codify local traditions or establish formal rules for new circumstances, commonly concerning social interactions, collective actions such as school repairs, and certain uses of land. It is believed by Madagascar historians that the dina's land tenure provisions are similar to the traditional tenure systems established by the Antanosy before French colonization when villagers were forced to accept foreign ideas of land distribution and use. A dina is usually written by the president of a fokontany, and approved by the community through the votes of lineage heads.

In the study area, the Malagasy Forest Service had established general boundaries for national parks, protected areas, and classified forests. Within these systems villagers could exert further control on the use of their local natural resources. In 1995, a dina limiting the area of forest that could be used for forest product extraction, agricultural fields and grazing was created by the Fokontany of Tamboro. This dina was created with input from local Forest Service officials to aid the villagers in making ecologically sound decisions about forest use. The Forest Service assisted as the need to protect these watersheds is consistent with their mission to conserve Madagascar's remaining forests.

Land is owned by family groups who are descendants of the original inhabitants of the region of Tamboro. Previously family members simply chose where they wanted to farm and claimed the land by ***miasa-tany*** (turning the soil). Currently, most of the arable land is under ownership by family groups, and people new to the region must pay in Malagasy francs for the land or be given it as a gift by one of the older family groups.

Any person who attempts to occupy another person's land is in violation of these land tenure rules and must pay a cash fine to the person, fokontany, or National Malagasy Forest Service. The same penalties apply to people who try to farm areas of the forest designated by the dina as non-cultivated. Although farmers are fined and must relinquish the land, the forest is not necessarily protected, because burning has most likely already occurred by the time the community becomes aware of the violation. So although violators have to atone monetarily for their errors, in reality it is all the users of the watershed who suffer.

While a dina may include rules concerning some natural resources, it does not govern all of them or all their uses (Durbin 1990). In certain situations for example, villagers make their own decisions about natural resource management, including decisions such as how and when to plant what their fields. These less formal land use rules play an important role in management of the forest near Tamboro, including organization of agricultural fields and water rights. They are unwritten, communicated verbally, and enforced within the community with no formal outside influence. Rules are enforced through community meetings where violators are compelled to pay in Malagasy francs, rice, or cattle to compensate for their violation.

Normally, individuals or family groups own ditches or canals between rice paddies that are fed by a river that was channeled during the colonial period. The canals are built and maintained by the people whose rice paddies they border. If one person violates another's agricultural or water rights, they must pay a fine to the person or family directly affected. If the violation affects the community's resources, for example the building of an unauthorized canal, then the fine is paid in cash to the community as a whole and used for projects such as repairing the school.

The Relationship between Proximity and Tenure Rights.—People in all seven villages of the Fokontany make use of the forest on at least a weekly, if not daily, basis to collect forest products either for individual family use or for sale at the local market. The proximity of a hamlet to the forest influences the frequency with which the forest is visited. Most villagers living within half a kilometer of the forest visit it twice a day. By comparison, villagers living two kilometers from the forest might visit it every two days. Both men and women feel that it is not safe for women to go into the forest to collect medicinal plants or do any type of agriculture; however this restriction does not seem to involve tenure.

Proximity to the forest also plays a substantial role in the emphasis villagers place upon their relationship to the forest and the use of its products. People living closer to the forest showed more interest in how it was managed than villagers located farther from the forest. An example can be seen during the creation of the previously mentioned dina, wherein people from the three villages closest to the forest were more involved than people from other villages.

Neither formal nor informal land rights restrict housing sites. These sites appear to be fairly flexible; consistent with the patrilocality of the society, most sons build their own house within the same hamlet as their parents.

Forest Products Important to Tamboro.— Five use categories evolved from interviews where people were asked to list the forest products that they relied on to meet their everyday survival requirements: firewood, construction materials, tools, medicinal plants, and wild foods. Within these categories the diversity of plant species used by villagers varied. For example, of the 355 species mentioned by villagers, 37% are used for medicinal purposes, whereas only 3% of this total are used for ceremonial purposes (Figure 2). These data indicate that there may be enough diversity of medicinal plant species so that no one species is over-harvested. The low number of plant species available for ceremonial purposes may be insufficient to meet the needs of the entire local populace, and may put stress on those plant populations. Further research, however, on the rate of use and

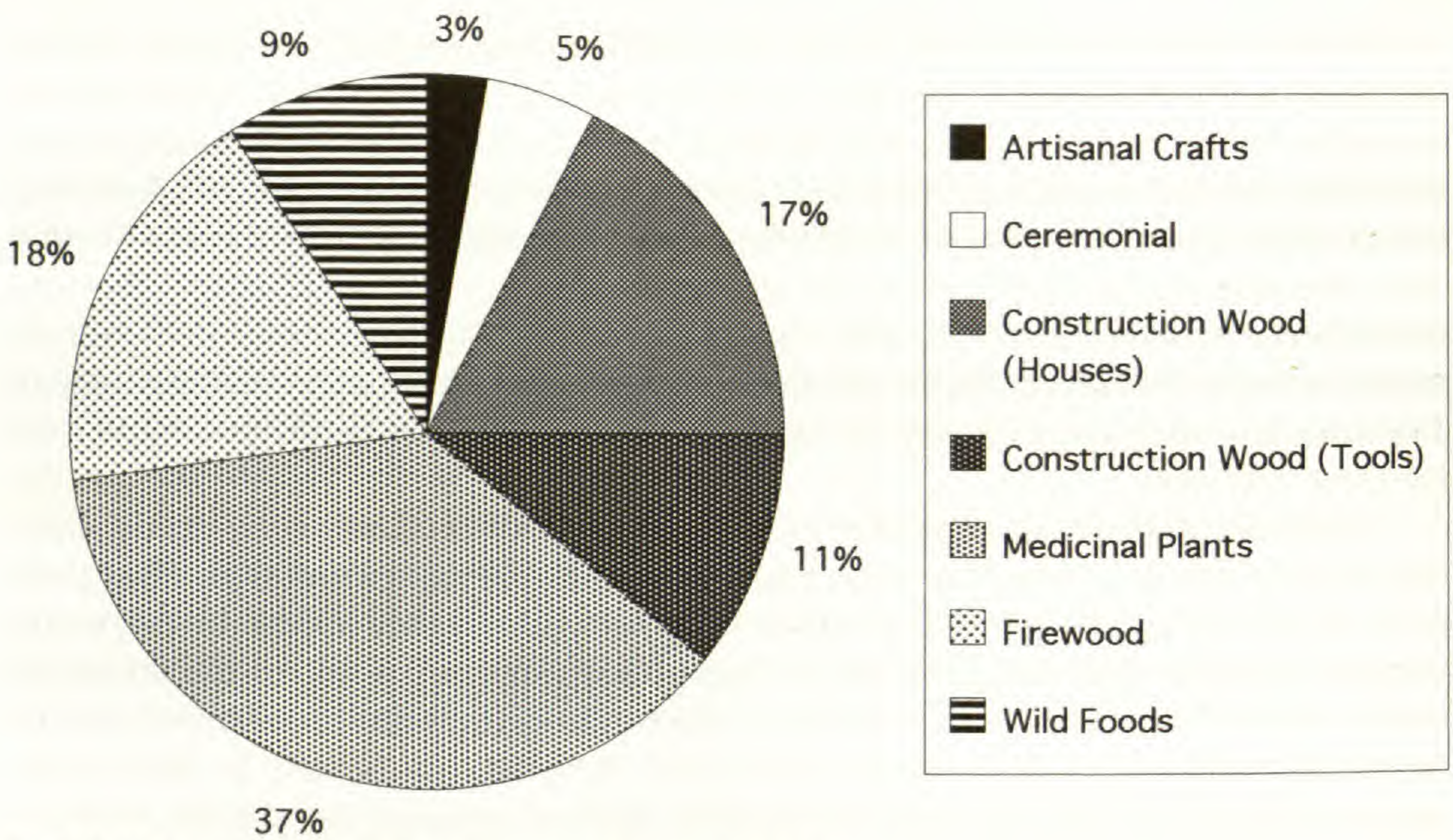

FIGURE 2.—Diversity of plant species used by villagers.

density of a given species would be necessary before this could be verified. Although traditional tenure and land use systems regulate forest production extraction and use, in the face of Madagascar's increasing population this system may not be adequate to protect particular species from being over-harvested.

Firewood. Men collect firewood near where they live. Thus, men from the four villages closest to the forest collect most of their firewood there, while men from the other villages collect wood alongside abandoned rice paddies. Villagers explained that this is a matter of convenience, but hamlet location itself is strongly influenced by tenure and kinship. People do not search for particular woods; rather fuel choice depends on what grows in the collection area. Within that constraint, ***voasary*** (*Citrus depressa* Bory.), ***kininy*** (*Eucalyptus citrodera* Hook.) and ***vontaky*** (*Strycnos spinosa* Lam.) are the preferred firewood species due to their hot flame and long burning time, but many other tree species are also used. Even though trees or branches are sometimes cut green, the fact that a broad range of species is acceptable for firewood might prevent a fuel shortage. Villagers explained that no species used for firewood is harder to find now than in the past, which suggests that there has not been serious pressure on the forest due to demands for firewood.

Construction materials. Villagers prefer cement houses due to their resistance to the elements, but more often have wood and ***ravenala*** (*Ravenala madagascariensis* Adans.) thatch houses. We have seen houses made of wattle and daub; although they are inexpensive to build, they are less common because they are more difficult to maintain.

Almost all construction materials are collected by young men from the forest and land tenure does not appear to influence collection except in areas where government restrictions within the classified forest apply. Men from all villages make use of all areas of the forest to find building materials. Planks for doors and windows are made from large, durable wood species such as ***grevillean*** (*Grevillea banksii* R.Br.). Most people use the hardwoods ***magnary*** (*Dalbergia* sp.) or ***kininy*** for framing. Due to their strength and resistance to termites, replacement of these timbers is usually not necessary for at least 15 years. ***Ravenala*** leaves are used as a roofing thatch, and the stems are used as sheathing for the walls. Cord for the roof thatch is peeled bark or lianas of species such as ***taikafotsy*** (*Grewia* sp.).

Of all the forest products extracted from the watershed, only those species used for construction wood are reported to be harder to find than they were 10 years ago. These results indicate a degree of scarcity because of local pressure for construction wood. People feel that large ***ravenala*** trees are still available in the forest, but had become scarcer. Consequently, the availability of cash had become a limiting factor in construction, as most people had to buy the leaves and stems of ***ravenala*** at the local market rather than collect their own supply. ***Ravenala*** was sold at the market by men from other fokontanies around the classified forest.

Tools. As with construction materials, there do not appear to be any restrictions on the collection of wood for tools based on land ownership. Men of all ages collect wood as necessary to keep themselves supplied with adequate tools for working in their fields. Several varieties of wood are used to create handles for the tools used in farming and building. ***Voandelaky*** (*Melia azedarach* L.) is the favorite species of wood for axes, shovels and other tools requiring a very strong handle.

Medicinal plants. Generally middle-aged to older men and women use medicinal plants extensively (Randrianarisoa 1996). Younger men and women are not as familiar as their elders with even the most basic plant remedies. Plants can normally be found growing wild near villages or in the forest. No villagers reported planting specifically for medicinal uses. Most people know of at least a few plant remedies for common ailments such as diarrhea, fever, eye infections and burns, and rely on traditional healers or go to the hospital when faced with a more serious or unusual illness.

Traditional healers know the most remedies made with plants, but their occupation does not give them more exclusive collection rights. Members of particular families were aware of more remedies than other families, but collection rights appeared to be fairly equal. Men do more collection of forest plants, such as *Asplenium* sp., but overall women do more collection and preparation of medicinal plants.

Traditional healers and villagers reported no decrease in medicinal plant availability or fear of a future decline. This stability could be due in part to the fact that most remedies require only parts of a plant so medicinal plants survive harvesting. Stability could also be due to substitution. Most illnesses can be treated with a variety of plants, and Western medicines are also used. Some western medicines are preferred for particular illnesses as most people feel Western medicine is more reliable than plant remedies. Yet western medicine is not used more frequently than traditional medicine, perhaps because of the cost. Further research is currently underway to determine the potential for using medicinal plants as an indicator for forest product scarcity.

Wild foods. Informal land tenure rules affect the harvesting of fruit. Normally, villagers only plant trees on their own land, and ownership of fruit trees is given to the owner of the land. This is, however, dependent on the type of tree. Valuable native and cultivated fruit trees—litchi (*Litchi sinensis* Radlk.), banana (*Musa* sp.)

(Figure 3), and coffee (*Coffea* sp.)—usually have strict access rights and only the family owning the land under the tree is allowed to harvest the fruit. The fruit of the litchi trees is of such high value that the family may have a guardian watch over them during harvest season. There were no banana or litchi trees growing near the villages that did not belong to a particular family. Occasional theft occurs, but is fairly difficult to accomplish without the thief being seen. Violators usually have to pay the owners of the tree with money or equivalent compensation. Other valuable fruit trees cultivated around the village include; coconut (*Cocos nucifera* L.), papaya (*Carica papaya* L.), ***corossolier*** (*Annona muricata* L.), and avocado (*Persea americana* Mill.). Although these trees are not as valuable as litchi, banana and coffee, they are still economically important to lower income families who sell the fruit to supplement their income.

Less valuable fruit trees, including oranges (*Citrus sinensis* Osbeck), lemons (*Citrus limon* L.Burm), mandarins (*Citrus reticulata* Blanco), guava (*Psidium* sp.), mangoes (*Mangifera indica* L.), tamarind (*Tamarindus indica* L.), and jack fruit (*Artocarpus integrifolia* L.f.), are cultivated and can be found growing wild in or around villages. Their market value is lower due to their relative abundance. Most of these species, although introduced, are considered common property resources even if they are located on a particular family's land. Often their ownership history is no longer known or they may have propagated naturally.

DISCUSSION

The traditional land tenure system plays a role in the use of most forest resources by the Antanosy at this time. Although the rigidity of land tenure seems to depend on the resource (i.e., water, fruit, land), land tenure controls all aspects of forest use. Dinas are used by the Antanosy to manage particular aspects of forest resource use within the constraints of the local tenure system. The 1995 dina was designed to conserve a particular area of the watershed to protect the tributaries that feed a larger water source. In order to protect the river that provides irrigation for most farmers, all Tamboro villagers agreed to, and thus are bound to obey, a dina that restricted all citizens' use of the forested land near the tributaries. This arrangement demonstrates that it is possible for the Antanosy to collaborate and maintain community level management decisions pertaining to land tenure.

Often community-based conservation projects designed by researchers and development agents fail to incorporate the traditional tenure systems practiced by local people into conservation efforts. Such projects frequently fall short of identifying local people's needs and conservation issues (Stevens 1997). This is because these projects often take into account only formal or government systems of land use, which might conflict with traditional management systems. Exploring communities' existing land use systems can help identify critical issues and reveal how local tenure systems can support conservation goals.

Given the rapid rate of environmental destruction in Madagascar, urgent attention is being given to conserving the country's remaining natural resources. The information developed in this study suggests an important key to curtailing Madagascar's loss of the rain forest. Local, traditional systems of land tenure and resource allocation may exist that can be an obstacle or an asset to development

FIGURE 3.—Man from the Fokontany of Tamboro with harvested forest foods (*Musa* sp. on the left and and *Manihot esculenta* on the right). Photograph by Linda Lyon.

efforts. Although this research is specific to the people of Tamboro, all those working on community-based conservation projects in Madagascar and other nations should understand, and when possible work within, functioning tenure and land use systems to enhance the long-term success of conservation projects.

NOTES

[1] Informal land tenure is defined as bundles of individual rights that determine the use and ownership of particular resources. Within the informal land tenure system a collective group of individuals or a family group may own a resource (i.e., land), but individuals not within these groups may have ownership of a part of this resource (i.e., trees on the land). It is also important to note that often informal land tenure can exist within a formal (legal) land tenure system or might override such a system depending on the stability and enforcement of the formal system.

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Journal of Ethnobiology 22(2): 285–306 Winter 2002

ETHNOICHTHYOLOGY AND FISH CONSERVATION IN THE PIRACICABA RIVER (BRAZIL)

RENATO A. M. SILVANO and ALPINA BEGOSSI
Núcleo de Estudos e Pesquisas Ambientais, University of Campinas, C. P. 6166, CEP: 13083 970, Campinas (SP), Brazil

ABSTRACT.—The impounded portion of the Piracicaba River sustains a recently established small scale fishery. The aims of this work are to verify the knowledge of Piracicaba River fishermen about fish biology and behavior, and to compare this knowledge to scientific information. We interviewed 22 fishermen with questionnaires and photographs of ten fish species. The fishermen showed a detailed knowledge about fish diet, predators, spatial and temporal distributions, reproduction and migratory patterns. Fishermen know better the common and commercially valuable fishes than the rare ones. Important factors influencing local ethnoichthyological knowledge are the value and abundance of the fishes, their usefulness in the fishery, and the frequency with which fishermen observe some of the biological attributes (such as feeding habits) of fishes. Much of the folk knowledge agreed with observations from the scientific literature. Fishermen understand the trophic relationships among native and exotic fish species, and they know the migratory patterns and the habitat preferences of the most valuable fishes. Such folk information may contribute to fishery management strategies. These results show that the folk knowledge held by small scale tropical fishermen is important for improving biological research.

Key words: Ethnobiology, tropical freshwater fishes, fishery, reservoir, freshwater fishermen.

RESUMO.—A região represada do Rio Piracicaba sustenta uma pescaria comercial de pequena escala, estabelecida recentemente. Os objetivos deste trabalho consistem em: verificar o conhecimento que os pescadores do Rio Piracicaba possuem sobre a biologia e comportamento dos peixes e comparar este conhecimento popular com as informações científicas. Foram entrevistados 22 pescadores, através de questionários baseados em fotografias de dez espécies de peixes. Os pescadores entrevistados apresentaram um conhecimento detalhado sobre a dieta, predadores, distribuição espacial e temporal, reprodução e padrões migratórios dos peixes. Os pescadores conhecem melhor os peixes comuns e de valor comercial do que as espécies raras. O valor e a abundância dos peixes, sua utilidade para o pescador, bem como a observação freqüente pelo pescador de atributos biológicos das espécies abundantes, são fatores importantes influenciando o conhecimento etnoictiológico local. Muitas das informações oriundas dos pescadores encontram-se de acordo com observações registradas na literatura científica. Os pescadores conhecem bem as relações alimentares entre espécies de peixes nativas e exóticas, bem como os padrões migratórios e habitats preferenciais dos peixes mais valiosos. Estas informações populares podem contribuir para estratégias de manejo da pesca. Estes resultados demonstram que mesmo pescarias tropicais de pequena escala e estabelecidas recentemente são importantes como um recurso cultural, que deve ser utilizado para guiar e auxiliar na pesquisa biológica.

RÉSUMÉ.—La zone de retenue du fleuve Piracicaba soutient une récente pêcherie de petite échelle. Cette étude a pour but de déterminer la connaissance des pêcheurs du fleuve Piracicaba en matière de biologie et de comportement des poissons et de comparer cette connaissance populaire aux informations scientifiques. Nous avons interviewé 22 pêcheurs en utilisant des questionnaires et les photographies de dix espèces de poissons. Les pêcheurs interrogés ont démontré une connaissance détaillée de l'alimentation des poissons, de leurs prédateurs, de leur répartition géographiques et temporelle, et de leur mode de reproduction et de migration. Les pêcheurs connaissent mieux les poissons ordinaires et les poissons commerciaux que les espèces rares. L'ethnoichtyologie locale dépend essentiellement de la valeur marchande et de l'abondance des poissons, de leur utilité pour les pêcheries, et de la fréquence avec laquelle les pêcheurs observent certains des attributs biologiques des poissons—modes d'alimentation par exemple. Les connaissances populaires correspondent en grande partie aux observations scientifiques. Les pêcheurs comprennent les relations alimentaires entre les espèces indigènes et et les espèces exotiques et ils connaissent les modes de migration et l'habitat préféré des poissons les plus prisés. Les résultats de cette étude montrent que les connaissance populaire dans les pêcheries tropicales de petite échelles peuvent contribuer aux stratégies de gestion des pêcheries et aux progrès de la recherche biologique.

INTRODUCTION

Ethnobiological studies have been furnishing new biological information about insects (Posey 1983), reptiles (Goodman and Hobbs 1994) and fish (Johannes 1981). Such information, if properly interpreted using a biological sciences framework, may be useful to biologists (Johannes 1993). Biological folk knowledge remains little studied, and is being threatened by the disappearance of indigenous people or their customs, as well as by the influence of urbanization and market economy on resource-use strategies (Johannes 1978; Posey 1983; Wester and Yongvanit 1995).

There are two ethnobiological theories dealing with the basis of folk knowledge. The utilitarian view argues that people should know useful organisms with more detail (Hunn 1982). The mentalistic view states that folk knowledge is primarily influenced by factors other than the usefulness of the organisms, such as their abundance in the environment (Berlin 1992).

Ethnoichthyological research provides evidence that both river and marine small-scale fishermen have well established knowledge of fish biology and classification (Begossi and Garavello 1990; Johannes 1981; Paz and Begossi 1996). Comparative studies show that folk knowledge is usually in accord with scientific data (Marques 1991; Poizat and Baran 1997). For example, Pacific island fishermen's information regarding marine fish reproduction helped scientists in the management of fish stocks (Johannes 1981). Northeastern Brazilian fishermen mentioned that the estuarine fish *Arius herzbergii* eats insects (Ephemeroptera) during certain months of the year. This information was investigated and confirmed by fish stomach content analysis, thus revealing a new food chain for tropical estuaries (Marques 1991).

Biological research alone may not be sufficient to gather the amount of data required to manage most tropical nearshore marine fisheries, due to lack of time and money. In such cases, fishery management may be more successfully accomplished if it is also based on contributions from fishermen's knowledge (Johannes 1998). A similar situation occurs in tropical freshwater environments, such as South American rivers, where fishery management suffers from a scarcity of published information on fish biology (Bayley and Petrere 1989; Böhlke et al. 1978; Petrere 1989). In this context, ethnoichthyological studies may be a useful management tool, bringing to light information which may serve both as guidelines for biological research (Marques 1991; Poizat and Baran 1997) and as a quick and inexpensive way to assessing biological data (Chapman 1987; Johannes 1981, 1998).

Southeastern Brazilian rivers and reservoirs drain industrialized regions and have been harvested by fishermen, who typically live in small fishing villages located near urban centers (Castro and Begossi 1995; Silvano and Begossi 1998; Vera et al. 1997). Such villages can be regarded as small "cultural units," subject to a distinctive set of political, economic, social and ecological characteristics. The small scale commercial fishery at the impounded Piracicaba River is of relatively recent origin, as it started around 1962 with the creation of the Barra Bonita Reservoir (Torloni 1994). This fishery has been threatened by environmental modifications such as dam construction, pollution and deforestation (Silvano and Begossi 1998). It is likely that the fishery will decline, with a concomitant loss of folk knowledge; this has already happened in the polluted upper Piracicaba River (Silvano 1997). We believe that such knowledge should be documented, considering its potential usefulness for fish conservation. The main objective of the present study is to document the knowledge of Piracicaba River fishermen about fish biology and behavior. We also intend to investigate the basis for such knowledge, to compare it with ichthyological scientific data, and finally to point out some ethnoichthyological information that may be applied to fishery management.

METHODS

The Piracicaba River in Southeastern Brazil is 115 km long, draining an urbanized region and receiving discharges of industrial effluents and domestic sewage. Barra Bonita Reservoir, created in 1962 with the damming of the lower Piracicaba River, has small fishing villages with active fishermen living along its banks (Silvano 1997). We carried out this study in two of these villages: Tanquã and Ponte de Santa Maria da Serra (Figure 1), inhabited by six and seven fisher families, respectively. These villages are located about 100 km from the city of Piracicaba, São Paulo State, southeastern Brazil. For details about the location of the study sites see Silvano and Begossi (1998). Many houses in both villages belong to tourists, being visited only during weekends and vacations (Silvano 1997).

We interviewed men and women who fish now or had fished in the past. We developed a standardized questionnaire with six questions about fish diet, pred-

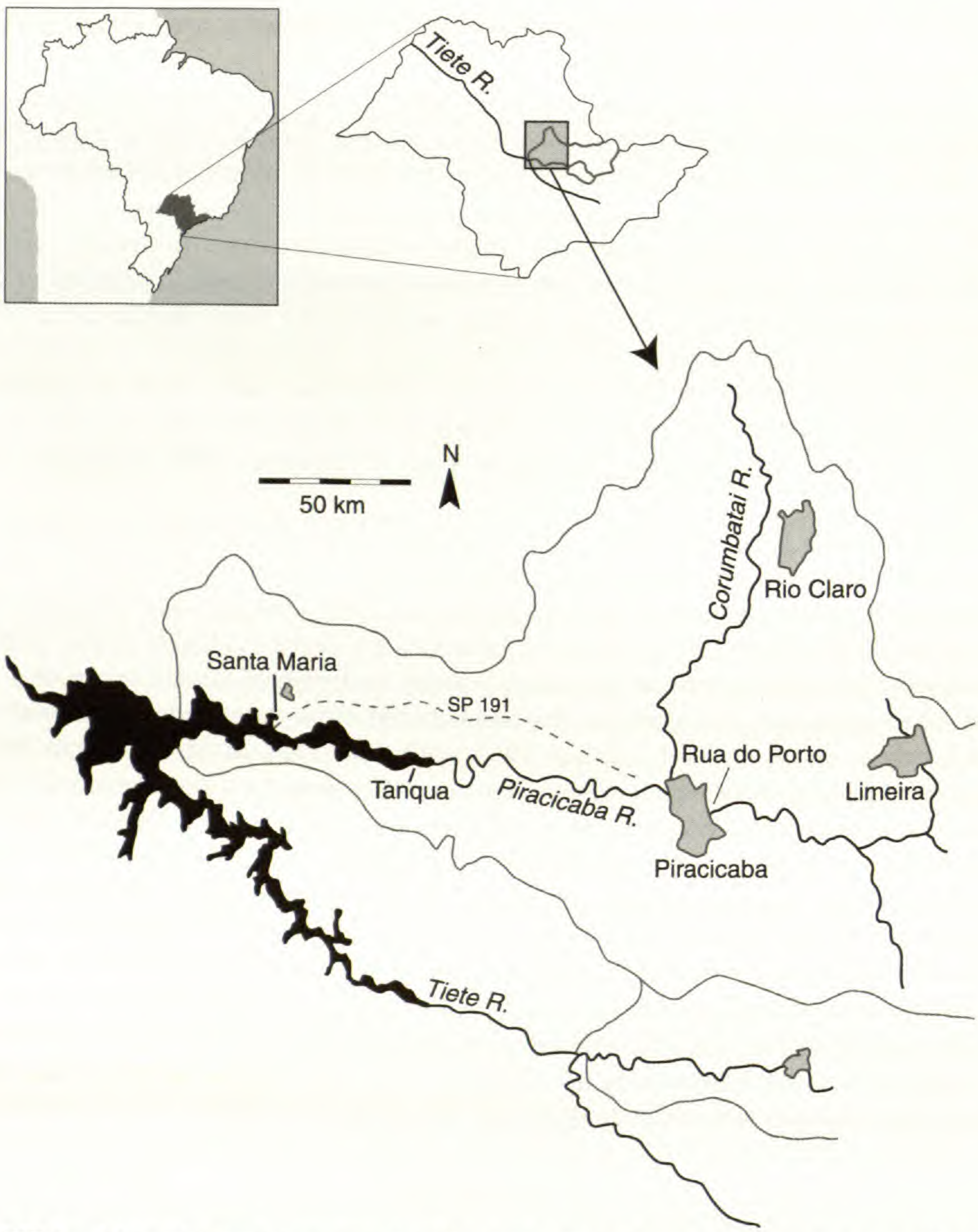

FIGURE 1.—Map of Brazil showing the Piracicaba River basin and the fishing villages of Tanquã and Ponte de Santa Maria da Serra.

ators, seasonal occurrence, habitats, reproduction, and migratory movements. The questions were asked in a manner understandable by the interviewed fishermen, who were allowed to answer in as much time they wanted. For each fish, a color photograph was shown, in the same randomized order for all people interviewed. The questions were:

1) What is the name of this fish?
2) What does this fish eat?
3) Which animals or other fishes prey on this fish?
4) Where does this fish live?

TABLE 1.—Fish species used for interviews, with their abundance and economic value.

Fish species	Family	Common name	n[a]	Abundance % (kg)[b]		Economic value[c]
Astyanax bimaculatus	Characidae	***lambari***	21	10	(679)	medium
Hoplias malabaricus	Erythrinidae	***traíra***	22	5	(363)	medium
Liposarcus aff. *anisitsi*	Loricariidae	***cascudo*** (horn-scaled catfish)	22	11	(801)	medium
Pimelodus maculatus and *P. fur*	Pimelodidae	***mandi*** (catfish)	20	14	(955)	low
Plagioscion squamosissimus	Sciaenidae	***corvina***	21	18	(1289)	medium
Prochilodus lineatus	Prochilodontidae	***corimba***	20	32	(2221)	medium
Rhamdia sp.	Pimelodidae	***bagre*** (catfish)	22	0.1	(5)	low
Salminus maxillosus	Characidae	***dourado***	22	0.8	(53)	high
Steindachnerina insculpta	Curimatidae	***saguiru***	22	0.6	(43)	none
Tilapia rendalli	Cichlidae	***tilápia***	21	0.04	(<5)	low

[a] n = sample size (number of interviewed fishermen).
[b] Values are percent of total fish mass landed in the two fishing villages, during 1994–1995 (Silvano 1997; Silvano and Begossi 1998).
[c] Economic value was assigned to the following categories: none (discarded fish), low (US$ 0.60–0.90 per kg), medium (US$ 0.90–4.40 per kg) and high (more than US$ 4.40 per kg).

TABLE 2.—Comparison of the number of doubts among ten fish species ($\chi^2_{9;\,0.05} = 57; p < 0{,}01$) and six biological attributes ($\chi^2_{5;\,0.50} = 120; p < 0{,}01$).

Fish species	Number of doubts	Biological attributes	Number of doubts
Astyanax bimaculatus	9	diet	23
Hoplias malabaricus	8	habitat	4
Liposarcus aff. *anisitsi*	11	migration	23
Pimelodus spp.	9	predators	4
Plagioscion squamosissimus	8	reproduction	66
Prochilodus lineatus	8	seasonal occurrence	13
Rhamdia sp.	23		
Salminus maxillosus	12		
Steindachnerina insculpta	9		
Tilapia rendalli	36		

5) When is this fish found here?
6) Does this fish move along the river? To where?

Duration of interviews varied, depending on the knowledge and objectivity of the interviewed person. We selected ten fish species for study among the 43 registered in the Piracicaba River fish landings (Silvano 1997). They represent a wide range of fishes that are common and rare, native and exotic, great and small in size, valuable and discarded (Table 1). Comparisons along these gradients should provide some insight into factors influencing the acquisition and maintenance of fishermen's folk knowledge. The number of interviewed people varied slightly for the different fish species because some people could not complete the questionnaire. We compared fishermen's information with data from the scientific literature, following Marques (1991). All fish mentioned in this study were collected and identified for verification.[1] The zoologist Ivan Sazima[2] identified the mammals and reptiles cited as fish predators, which were not collected.

Answers given such as "I do not know" (DNK) were considered uncertain knowledge. Considering that fishermen should best know the fish species or biological aspects with the smallest number of DNK, we compared the number of DNK answers among the fish species and the biological attributes through a chi-square test.

RESULTS

We interviewed 17 men and 5 women, corresponding to about 80% of the resident fishers in the two villages. The common and scientific names, abundance, and economic value of the ten fish species studied are listed in Table 1. Of these, the ***cascudo*** (horn-scaled catfish–*Liposarcus* aff. *anisitsi*, Loricariidae [Figure 2]), the ***corvina*** (*Plagioscion squamosissimus* [Heckel], Sciaenidae [Figure 3]) and the ***tilápia*** (*Tilapia rendalli* [Boulenger], Cichlidae) are exotic to the Piracicaba River basin. Considering the great variety of answers gathered, we show only those mentioned by at least 20% of interviewees.

Factors Influencing Folk Knowledge.—Fishers showed more doubts (less knowledge) about *Tilapia rendalli* and *Rhamdia* sp. ($\chi^2_{9;\,0.05} = 57; p < 0.01$; Table 2), which were

FIGURE 2.—The ***cascudo,*** *Liposarcus* aff. *anisitsi.*

FIGURE 3.—The ***corvina,*** *Plagioscion squamosissimus.*

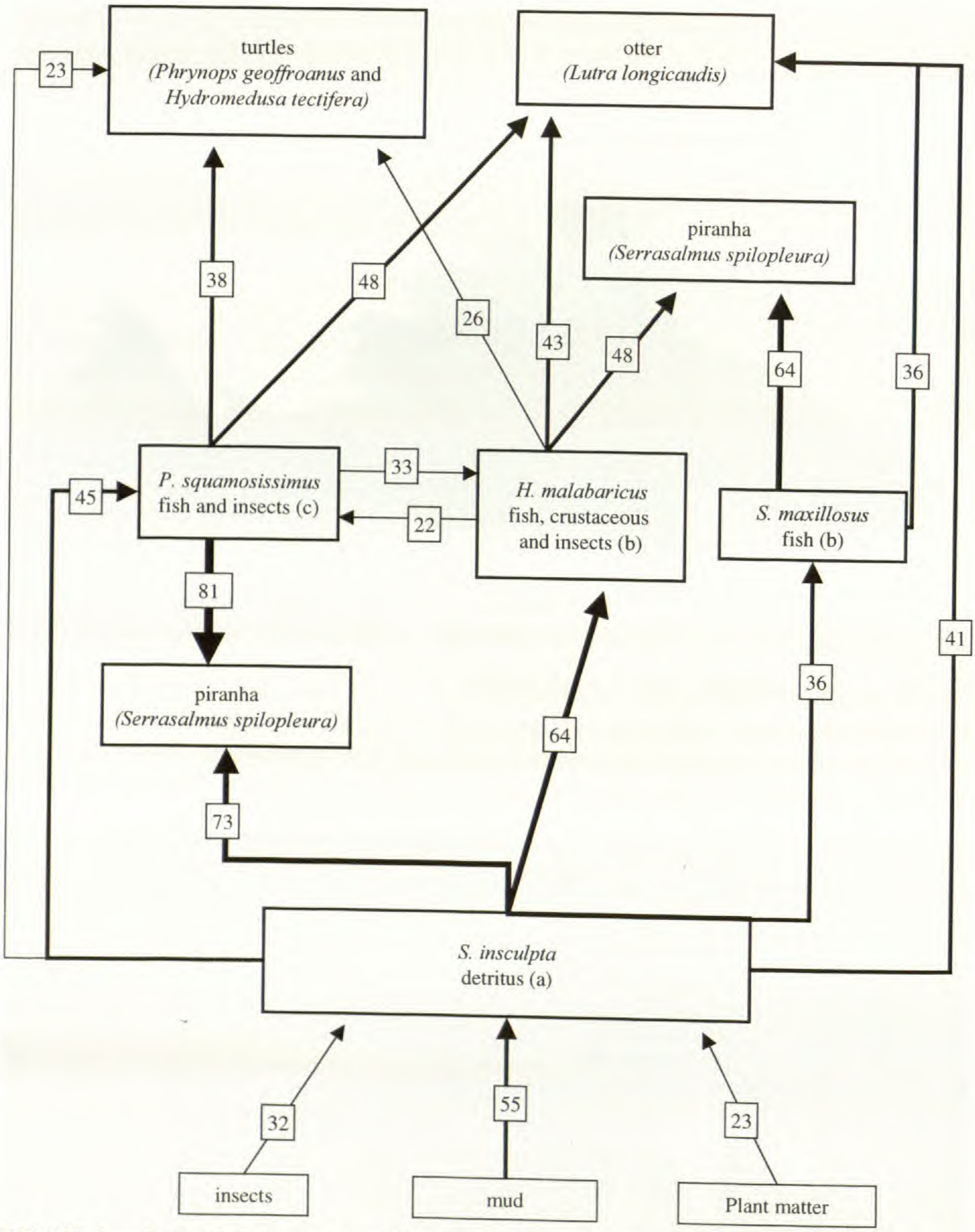

FIGURE 4.—A simplified model of the food web in the Piracicaba River, following fishermen's information about ***saguiru*** diet and predators. Numbers inside small boxes correspond to the percentage of interviewees that mentioned the respective trophic link. Below the scientific names of some of the fish, are fish diets reported in the scientific literature; letters refer to sources: (a) Fugi et al. 1996; (b) Bistoni et al. 1996; (c) Braga 1995.

TABLE 3.—Feeding habits of the Piracicaba River fishes according to the interviewed fishermen.

Food items	Consumers												
	Tilapia rendalli	*Astyanax bimaculatus*	*Steindachnerina insulpta*	*Prochilodus lineatus*	*Liposarcus* aff. *anisitsi*	*Rhamdia* sp.	*Pimelodus* spp.	*Salminus maxillosus*	*Plagioscion squamosissimus*	*Hoplias malabaricus*	Otter	Piranha	Turtles
plant matter	33	29	23	.	.	.	.	.	.	.	.	.	.
mud	48	.	55	85	86	36	65	.	.	.	.	.	.
insects	.	52	32	.	.	.	25	.	.	.	.	.	.
earthworms	.	.	.	.	.	.	40	.	.	.	.	.	.
unspecified fishes	.	.	.	.	.	41	30	.	.	.	.	.	.
Tilapia rendalli	.	.	.	.	.	.	.	.	.	24	29	52	29
Astyanax bimaculatus	.	.	.	.	.	.	.	45	75	80	35	70	35
Steindachnerina insculpta	.	.	.	.	.	.	.	36	45	64	41	73	23
Prochilodus lineatus	.	.	.	.	.	.	.	.	20	.	80	65	35
Liposarcus aff. *anisitsi*	.	.	.	.	.	.	.	.	.	.	22	.	.
Rhamdia sp.	.	.	.	.	.	.	.	.	.	.	48	57	.
Pimelodus spp.	.	.	.	.	.	.	.	.	45	.	70	75	40
Salminus maxillosus	.	.	.	.	.	.	.	.	.	.	36	64	.
Plagioscion squamosissimus	.	.	.	.	.	.	.	.	.	33	48	81	38
Hoplias malabaricus	.	.	.	.	.	.	.	.	22	.	43	48	26

Note: The numbers correspond to the percentage of interviewees who mentioned the respective trophic interaction.

rare and of low economic value (Table 1). Some of the best known fish species are of high economic value, such as the ***traíra*** (*Hoplias malabaricus* [Bloch], Erythrinidae), *Plagioscion squamosissimus,* the ***corimba*** (*Prochilodus lineatus* Steindachner, Prochilodontidae), and the ***lambari*** (*Astyanax bimaculatus* [Linnaeus], Characidae), or are abundant in the fish landings, such as the ***mandi*** (catfish–*Pimelodus* spp., Pimelodidae; Tables 1 and 2). Considering biological aspects, fishermen had more doubts about reproduction than about fish habitats and predators ($\chi^2_{5;\,0.05} = 120$; $p < 0.01$; Table 2).

Comparison of Folk Knowledge with Biological Literature.—A simplified folk food web for the Piracicaba River fishes was constructed, based on fishermen citations regarding fish diets and predators. Each link of the food web, represented by arrows, corresponds to a certain proportion of fishermen's responses during interviews. The width of the arrows reflects the proportion of citations referring to a particular feeding relationship. In Figure 4 and Table 3, the fish diets according to scientific literature (letters referring to the sources) are presented below the fish scientific names. There are four levels in the food web: primary consumers, primary carnivores, secondary carnivores and top predators, allowing the assignment of feeding guilds for the fishes. It was possible to distinguish food specialist (one or two kinds of food) from generalist (three or more kinds of food) fishes. Specialists were piscivorous (*Plagioscion squamosissimus, Hoplias malabaricus,* the ***dourado*** [*Salminus maxillosus,* Valenciennes]) and detritivorous (*Prochilodus lineatus, Liposarcus* aff. *anisitsi*) species. Generalists were omnivorous fishes such as *Pimelodus* spp., the ***bagre*** (a catfish—*Rhamdia* sp., Pimelodidae), and *Astyanax bimaculatus* (Characidae).

Fishermen mentioned about 23 species of fish predators, corresponding to 11 fishes, 5 birds, 4 reptiles and 3 mammals, the most cited being represented in Figure 4. Accordingly with, respectively 35, 26 and 17% of fishermen, ***piranhas*** (*Serrasalmus spilopleura* [Kner], Characidae; Figure 5), otter (*Lutra longicaudis* [Olfers]), and turtles (*Phrynops geoffroanus* [Schweigger] and *Hydromedusa tectifera* [Cope]) usually attack fishes that are entangled in the nets. The ***piranha,*** the most cited predator, preys on all ten fish species studied.

Fishermen mentioned a great diversity of habitats occupied by the fishes, which could be separated into lacustrine (*Hoplias malabaricus, Liposarcus* aff. *anisitsi, Steindachnerina insculpta, Tilapia rendalli*), stream (*Astyanax bimaculatus, Rhamdia* sp.), and river (*Prochilodus lineatus, Salminus maxillosus, Pimelodus* spp.) species, with *A. bimaculatus* and *Plagioscion squamosissimus* being mentioned as habitat generalists (see Table 4).

We observed that fishermen distinguished among migratory and sedentary fish species, and they recognized many kinds of fish migratory movements, from great longitudinal to short lateral migrations (Figure 6). According to fishermen's answers regarding seasonality, *Pimelodus* spp. occur mainly in the winter, *H. malabaricus* and *P. squamosissimus* were common during spring, whereas *P. lineatus* and *S. maxillosus* were most abundant in summer. The seasonal occurrence of the migratory *P. lineatus* and *S. maxillosus* was associated with rainfall (Table 5).

As mentioned in the section above, we had fewer answers about fish reproduction than about other biological characteristics. In spite of this, fishermen did

FIGURE 5.—The **piranha**, *Serrasalmus spilopleura*.

mention that the majority of Piracicaba River fishes reproduce during summer, which generally agrees with published data (Table 6).

DISCUSSION

Factors Influencing Folk Knowledge.—Our results indicate that the folk knowledge of Piracicaba River fishermen is more detailed for abundant and useful species, especially those that are commercially valued. Similarly, river and maritime Brazilian fishermen classify useful fish with more detail (Begossi and Figueiredo 1995; Begossi and Garavello 1990).

With regard to biological aspects, information about fish reproduction may be difficult for Piracicaba River fishermen to acquire, since fish usually reproduce infrequently in time. Furthermore, knowing when fish lay eggs has no direct usefulness to the fishery. Conversely, information about fish habitat is important for the Piracicaba River fishermen, as a good catch depends on the fishermen's ability to set gillnets in appropriate places. Elsewhere, researchers have shown that knowledge about fish spatial distribution influences river, maritime and estuarine fishing strategies (Chapman 1987; Marques 1991; Petrere 1990). Techniques of attracting wanted fish species by increasing aquatic habitat heterogeneity were documented for fishing communities from the northeastern Brazilian estuary (Marques 1991), African lagoons (Hem and Avit 1994) and India maritime coast (Cruz et al. 1994). Such habitat manipulation does not occur in the Piracicaba River fishery, perhaps due to its recent nature.

Piracicaba fishermen showed a good knowledge about the **saguiru** (*Steindach-*

TABLE 4.—Fish habitats accordingly to fishers' answers and scientific literature. Values in parenthesis are percent of fishermen that quoted a particular habitat. (Numbers of fishermen interviewed for each fish species are in Table 1.)

Fish species	Habitat according to fishermen	Habitat recorded in biological literature
Astyanax bimaculatus	stream (38), any habitat (29), main river channel (24), near the shore (24)	wide distribution; streams, temporary pounds, reservoirs, quiet and fast waters, surface and middle water (Uieda 1984; Agostinho et al. 1995)
Hoplias malabaricus	shallow waters (55), lagoon (50), among the vegetation (50), on the bottom's mud (50), near the shore (27)	lagoons, reservoirs, temporary pounds, shallow waters (Resende et al. 1996), among the vegetation, on the bottom (Uieda 1984), near the shore during dry periods (Fink and Fink 1979)
Liposarcus aff. *anisitsi*	rocks (55), lagoon (36), among the vegetation (36)	not found
Pimelodus spp.	main river channel (60), on the bottom (50), shallow waters (20)	main river channel, reservoirs (Agostinho et al. 1995) on the bottom (Barella et al. 1994)
Plagioscion squamosissimus	main river channel (38), on the bottom (29), any place (29), near the shore (24)	wide distribution; quiet water habitats, such as reservoirs and lagoons; among submerged rocks and gravel, open waters, near the shore (Torloni et al. 1993)
Prochilodus lineatus	among submerged logs (60), lagoon (30), main river channel (25)	adults occupy rivers, juveniles occurs in lagoons (Agostinho et al. 1995), feed on the bottom, among the vegetation and submerged logs (Fugi et al. 1996)
Rhamdia sp.	stream (45), main river channel (32), rocks (32)	streams (Agostinho et al. 1995), on the bottom near the shore (Costa 1987)
Salminus maxillosus	main river channel (59), fast waters (45), on the bottom (36), shallow waters (27)	Rivers, fast waters (Agostinho et al. 1995)
Steindachnerina insculpta	lagoon (36), shallow waters (32) near the shore (32), main river channel (27)	Reservoirs, on the bottom and at middle water (Agostinho et al. 1995)
Tilapia rendalli	lagoon (48), among the vegetation (38)	Streams, reservoirs, lakes, (Uieda 1984; Romanini 1989), shoals of juvenile fish in shallow waters near the shore, among the vegetation (Uieda et al. 1989)

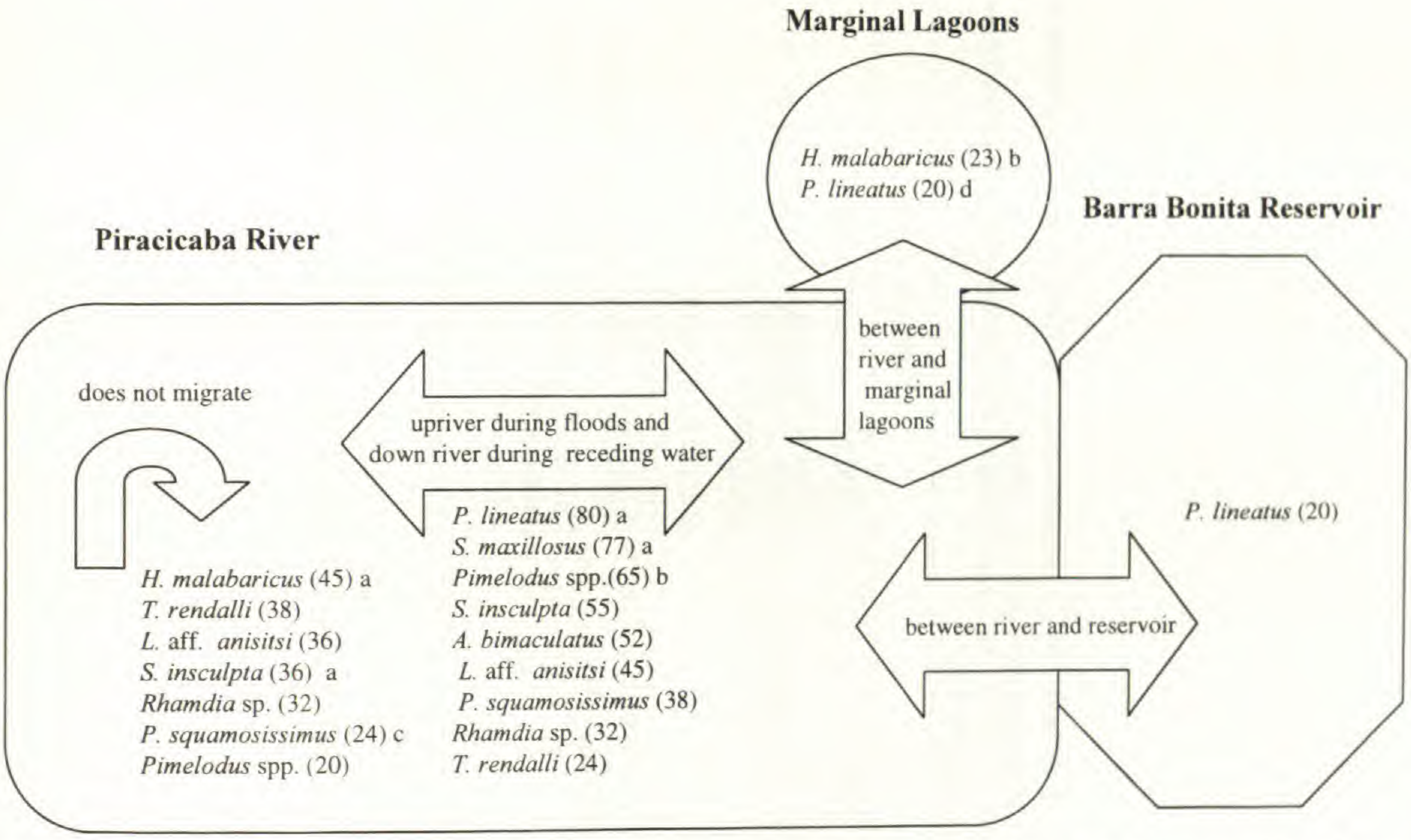

FIGURE 6.—Fish migratory movements according to Piracicaba River fishermen. Numbers in parentheses are the percentages of interviewees that pointed out the movement for the respective fish species. Letters refer to the scientific sources that agree with the information given by the fishermen: (a) Vazzoler and Menezes 1992; (b) Godoy 1975; (c) Petrere 1985; (d) Agostinho et al. 1995.

nerina insculpta; Table 2). This fish has no commercial value and usually is discarded. ***Saguiru*** (fishes from the Curimatidae family, including *S. insculpta*) comprised about 35% of the total catch in the Barra Bonita reservoir fishery during 1985 and 1986, declining afterwards (Silvano and Begossi 1998). This decrease in abundance suggests that ***saguiru*** could have been more abundant or important in the past. Besides this, knowing the habits and behavior of a prey species like *S. insculpta* can help Piracicaba fishermen to find larger piscivorous and valuable fishes, such as *Hoplias malabaricus, Plagioscion squamosissimus* and *Salminus maxillosus.* Amazon fishermen usually track small prey fishes in order to find the wanted piscivorous ones (Goulding 1979).

Fishermen also know in detail fish diets and predators (Table 2), although such information may not be directly useful, as Piracicaba fishermen usually do not use bait. Information about fish feeding relationships may have an indirect value in the fishery, however, as the diet of a fish is usually related to its habitat. Furthermore, fishermen can minimize fish loss from predator attacks if they avoid setting gillnets in places with high predator abundance. Notwithstanding such proposed usefulness, the observed detailed folk knowledge regarding feeding relationships can be also merely due to a high frequency of observation: fishermen frequently clean fish and see stomachs contents, and predators are also commonly observed eating fish entangled in the gillnets. Concerning the conflict of mentalistic versus utilitarian views in ethnobiology, Clément (1995) argued that both utility and observed criteria such as color and morphology could influence folk biological classification, being associated aspects of the same process. Perhaps this

TABLE 5.—Fish seasonal occurrence according with fishers answers and fish landing data (Silvano 1997). Values in parenthesis are the percent of fishermen that quoted a particular season. (Number of fishermen interviewed for each fish species are in Table 1.)

Fish species	Season of greater abundance[a]	
	Fishermen answers	Fishery data
Astyanax bimaculatus	summer (62), spring (43), wet season (29), all the year (29)	summer, autumn, spring
Hoplias malabaricus	spring (73), low water season (32), summer (27), winter (27)	winter, spring
Liposarcus aff. *anisitsi*	wet season (55), all the year (27), spring (27), winter (27), summer (23)	winter, spring
Pimelodus spp.	winter (55), summer (20)	winter
Plagioscion squamosissimus	spring (52), summer (38), winter (33), all the year (29)	autumn, spring
Prochilodus lineatus	spring (70), summer (55), winter (20), wet season (20)	spring, summer
Rhamdia sp.	wet season (36), summer (27), all the year (27), scarce (27)	autumn, winter, spring (scarce)
Salminus maxillosus	summer (45), wet season (32), spring (32), scarce (27)	summer (scarce)
Steindachnerina insculpta	summer (45), all the year (36), spring (27)	discarded
Tilapia rendalli	scarce (48)	winter (scarce)

[a] Seasons are defined as follows: summer (December, January or February), spring (September, October or November), wet season (from November to March), Low water season (from August to November), winter (June, July or August), autumn (March, May or April).

TABLE 6.—Fish reproductive period according to the fishermen answers and from the scientific literature. Values in parentheses are percent of fishermen that quoted a particular season. (Number of fishermen interviewed for each fish species are in Table 1. Seasons are specified in Table 4.)

Fish species	Reproductive period	
	Fishermen answers	Biological literature
Astyanax bimaculatus	summer (64), spring (50)	wet season (Godoy 1975)
Hoplias malabaricus	spring (55), summer (36)	September and October (Barbieri 1989)
Liposarcus aff. *anisitsi*	November (36), summer (32),	not found
Pimelodus spp.	spring (55), summer (45)	not found
Plagioscion squamosissimus	summer (32), all the year (23)	November to February (summer) (Braga 1997)
Prochilodus lineatus	summer (41), spring (41)	spring (November), summer (Agostinho et al. 1995)
Rhamdia sp.	spring (45), summer (32)	spring, summer (Narahara 1983)
Salminus maxillosus	spring (55), summer (50)	spring, summer (Godoy 1975)
Steindachnerina insculpta	summer (59), spring (50)	not found
Tilapia rendalli[a]	summer (18), spring (18)	not found

[a] For this species we present information quoted by fewer than 20% of the interviewees, as the majority of fishermen (59%) know nothing about its reproduction.

conclusion could be also applied to the Piracicaba River fishing villages studied. There, the acquisition of folk knowledge about fish may be associated with the frequency of observation of biological events, whereas diffusion and maintenance of this knowledge possibly depends on its direct usefulness for the fishermen.

Besides exploiting a recent and constantly changing environment, Piracicaba River fishermen exhibited a developed knowledge about fish, even for exotic species, such as *Plagioscion squamosissimus* and *Liposarcus* aff. *anisitsi*. This indicates that folk knowledge has been diffusing in quick and efficient ways among such small fishing villages in southeastern Brazil.

Comparison of Folk Knowledge with Biological Literature.—Piracicaba River fishermen recognized several trophic relationships among fishes. Such relationships form a complex food web, with approximately four levels and several links. Marques (1991, 1995) also recognized complex food webs, with five levels, based on the information provided by estuarine and river fishermen of northeastern Brazil. Tropical river fishes have complex and diverse trophic relationships (Lowe-McConnell 1987). At least some of this complexity is revealed through ethnobiological research, which indicates aspects deserving further investigation. According to the Piracicaba fishermen, detritus is at the basis of the food chain, being the main food for primary consumers and comprising the bulk of the diets of *Prochilodus lineatus* and *Liposarcus* aff. *anisitsi* (Figure 4, Table 3). This agrees with biological studies, which show that detritivorous fish, such as prochilodontids and loricariids, are the basis of many tropical aquatic food webs, being important in nutrient recycling (Bowen 1984; Catella and Petrere 1996; Flecker 1996). Thus we can expect, based on our ethnoichthyological information, that detritus is an essential energy source to Piracicaba River fish and fishery, as observed in other tropical, undisturbed wetlands (Duque et al. 1998).

The predatory fish *Serrasalmus spilopleura* was the main fish predator mentioned by the Piracicaba River fishermen, who said that *S. spilopleura* bites off pieces of fish, preferring caudal fins (according to 17% of interviewees). The proliferation of this fish may be an effect of Piracicaba River damming, as serrasalmids often increase in abundance after a river is dammed (Santos 1995; Sazima and Zamprogno 1985). As mentioned by Piracicaba River fishermen, *S. spilopleura* was observed feeding opportunistically on a variety of other fish species, mutilating the fishes and biting off pieces of the caudal fins (Sazima and Machado 1990; Sazima and Pombal 1988). At the Pantanal Wetlands, the serrasalmids exert a great influence on all fish communities, constraining the behavior and use of space of various fish species (Sazima and Machado 1990). Our results suggest a similar effect of *S. spilopleura* predatory behavior on the Piracicaba River fishes, which inhabited a dammed river.

The otter, *Lutra longicaudis,* was also quoted by most of the Piracicaba River fishermen as a fish predator. Emmons (1990) observed that *L. longicaudis* is an aquatic mammal that feeds predominantly on fish, with diurnal and nocturnal habits, inhabiting clear water and running rivers. Furthermore, this species is currently threatened, mainly by habitat destruction, and its biology and ecology are poorly known (Fonseca et al. 1994). Considering that *L. longicaudis* is usually rare in silt-laden lowland rivers (Emmons 1990), such as the Piracicaba, fishermen's information indicates that populations of this mammal species may still occur in the dammed and polluted Piracicaba River. This information may be useful in reinforcing the need to conserve and restore the ecological integrity of the Piracicaba River Basin, through reduction in water pollution and protection of the riparian forests.

Piracicaba River fishermen associated the seasonal occurrence of large migratory fishes with the rainfall period, thus using climatic clues to predict fish temporal abundance. In fact, an increase in rainfall is one of the factors that releases the reproductive stimulus and migratory behavior of these fishes (Agostinho et al. 1995; Welcomme 1985). Climatic factors, such as winds, floods and tides are essential clues to assess the migratory movements of the fishes that sustain estuarine fisheries in northeastern Brazil (Cordell 1978; Marques 1991) and even for a maritime turtle fishery in Nicaragua (Nietschmann 1972).

Piracicaba River fishermen also mentioned some unknown biological features, such as the timing of reproduction of *Pimelodus* spp. and *Tilapia rendalli*, the migratory movements of *Rhamdia* sp. and *T. rendalli*, and all the biological characteristics of *Liposarcus* aff. *anisitsi*. We also observed some contradictions between fishermen's answers and the biological literature, especially with respect to migratory behavior, an aspect poorly known to biologists. For example, fishermen mentioned *Astyanax bimaculatus* as migratory (Figure 6), although it has been regarded as sedentary (Vazzoler and Menezes 1992). In these cases, biological research could be conducted at the Piracicaba River in order to verify whether fishermen's assertions match scientific observations.

CONCLUSIONS CONCERNING ETHNOICHTHYOLOGY AND FISH CONSERVATION

As discussed previously, information acquired with Piracicaba River fishermen about fish biology is generally supported by the scientific literature, especially regarding fish diet and habitat. Even considering that biologists often deal with the same genus or species from other rivers, the observed concordance between folk and scientific knowledge indicates that folk knowledge probably approaches biological reality, and provides useful support for fishery management decisions. We thus could point out at least three areas where these results would be useful for fish conservation and fishery management actions on the Piracicaba and other rivers: seasonality, effects of exotic fishes, and fish migration and habitat.

Quick Appraisal of Seasonal Fish Occurrence.—Folk information about the seasonal occurrence of fish at the Piracicaba River agreed with fishery data recorded during one year (Table 5). This agreement indicates that an ethnoichthyological survey may be a useful way to monitor fish species abundance when there is not sufficient time or money to gather detailed fishery data or experimental fish samplings. Poizat and Baran (1997) also observed fishermen folk knowledge was consistent with the results of an experimental fishing survey concerning the spatial and temporal distribution of African estuarine fishes.

Estimates of the Effects of Exotic Fishes on Native Fish Fauna.—Invasion or introduction of fish into tropical rivers and reservoirs had been often prejudicial to the native ichthyofauna, which usually suffers the adverse effects of predation and competition from exotic species (Lowe-McConnell 1993; Stiassny 1996). Human induced environmental changes, such as the damming of a river, could favor the proliferation of exotic species (Crivelli 1995). Currently, there is lack of biological studies directed to the interactions with native and non-native fishes for the majority of Brazilian river basins where fish introductions have occurred. The ***corvina*** (*Plagioscion squamosissimus*) and the ***cascudo*** (*Liposarcus* aff. *anisitsi*) are exotic to the Piracicaba River basin, originating, respectively, in the Brazilian Amazon and Upper Paraná basins. While the former was intentionally introduced with the purpose of enhancing fishery yields (Torloni 1994), the latter possibly had invaded the Piracicaba River. The abundance of the ***corvina*** and the ***cascudo*** in the fish catches on the Piracicaba River increased respectively after 1986 and 1993 (Silvano and Begossi 1998). The dissemination of these exotic taxa probably had been affecting the native fish community, yet we do not exactly know the nature and extent of those effects. Although *P. squamosissimus* was studied by Braga (1995), the biology of *L.* aff. *anisitsi* remains unknown. In the present study we provided folk information about the biology of these two species. We believe that such information, if properly interpreted and checked with scientific findings, could help in the understanding of the interactions between exotic and native fish species in the Piracicaba River basin.

According to the majority of fishermen interviewed, detritus is a main food source for the exotic *Liposarcus* aff. *anisitsi* and the native ***corimbata*** (*Prochilodus lineatus*), suggesting that these two species may have been competing for food. This information should be tested through biological studies, considering the importance of the ***corimbata*** to the Piracicaba River fishery (Silvano 1997).

Small characiform fishes, such as *Astyanax bimaculatus* and *Steindachnerina insculpta,* were mentioned by Piracicaba fishermen as important prey species for piscivorous fish, including the introduced Amazonian fish, *Plagioscion squamosissimus* (Figure 4). Braga (1995) conducted a study of the *P. squamosissimus* diet through stomach contents analysis, observing that *A. bimaculatus* was one of its main food items. This feeding interaction was also mentioned by 75% of the Piracicaba River fishermen interviewed. Furthermore, respectively 80% and 45% of fishermen mentioned *A. bimaculatus* as food for *Hoplias malabaricus* and *Salminus maxillosus,* two native Piracicaba River piscivorous fishes (Table 3). This study thus indicates that the introduction of *P. squamosissimus* may have been adversely affecting the native Piracicaba River fish community, both through predation pressure on the *A. bimaculatus* population and competition for food with *H. malabaricus* and *S. maxillosus.* In other tropical freshwater habitats, such as the African lakes, the introduction of predatory fish species severely disrupted the fisheries and caused the extinction of many native fish species (Lowe-McConnell 1993).

Information about Fish Habitats and Migratory Behavior.—Piracicaba fishermen furnished information about fish habitat preferences and migratory routes. A considerable amount of effort is necessary to assess this kind of data through biological research. Piracicaba River fishermen mentioned that the aquatic vegetation is a habitat for *Hoplias malabaricus*, *Liposarcus* aff. *anisitsi* and *Tilapia rendalli* (Table 4), plus *Plagioscion squamosissimus* (19%), *Prochilodus lineatus* (15%) and *Steindachnerina insculpta* (18%). The aquatic vegetation is an important refuge and feeding ground for freshwater fishes (Junk et al. 1983; Lowe-McConnell 1987; Sazima and Zamprogno 1985), which reinforces the need for biological studies directed at corroborating or refuting the suggested importance of riparian and submerged vegetation for the Piracicaba River fishes.

There is need for detailed studies of fish migration in the Piracicaba and in other Brazilian rivers. Our results may help in filling this gap, as Piracicaba fishermen mentioned nine fish species as migrating up and down the river, especially *Prochilodus lineatus* and *Salminus maxillosus*; *P. lineatus* also moves between the river and marginal lagoons (Figure 6). Both these species must migrate in order to reproduce (Vazzoler and Menezes 1992), and juveniles of *P. lineatus* grow in marginal lagoons, moving to the river when adults (Agostinho et al. 1995). Fishermen's answers indicate that *P. lineatus* and *S. maxillosus* may be undergoing migrations in the Piracicaba River, in spite of the dam downstream. This hypothesis should be verified through migratory studies, in order to support management measures directed to ensure the continuity of the migrations and the reproduction of these two commercially important fish species.

Our study demonstrates that ethnoichthyological knowledge is not only restricted to indigenous fishing people, which harvest the same region over the course of centuries or millennia. Small-scale commercial fishermen also show a detailed folk knowledge, even over the course of a few generations. Tropical artisanal fisheries have been widely subjected to external influences, such as habitat degradation and market pressure, which have threatened not only the fish stocks, but also the fishing communities. It is an imperative task to document and interpret fishermen's folk knowledge, especially in the tropics, for it could enable scientists to work together with fishermen in devising measures aimed at conserving both the fish and fishing culture.

NOTES

Erratum. In this article, the term "fishermen" designates both the men and the women interviewed in the Piracicaba River fishing communities.

[1] Voucher specimens are deposited at the fish collection of the Museu de Zoologia da Universidade de São Paulo (MZUSP), CP 42694, 04299-970, São Paulo (SP), Brazil. Only *Salminus maxillosus* was not collected; it was identified with color photographs.

[2] Dr. Ivan Sazima, Departamento de Zoologia and Museu de História Natural, Universidade Estadual de Campinas, C.P. 6109, 13083-970, Campinas (SP), Brazil.

ACKNOWLEDGMENTS

Thanks are given to the fishermen from Ponte de Santa Maria da Serra and Tanquã for their friendship and kindly collaboration for this work, to L. Sanchez, who introduced R.A.M.S. to the fishers; to O. T. Oyakawa, for help with fish species identifications, to I. Sazima, for help with fish species identifications and valuable suggestions, to M. Petrere

Jr. and M. M. Habib for valuable suggestions; to CAPES and FMB for scholarships to R.A.M.S., to CNPQ for a research productivity scholarship to A.B., and to FAPESP and PADCT-Finep for financial support of the fieldwork.

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Plant Exploitation on Epipalaeolithic and Early Neolithic Sites in the Levant. Sue Colledge. 2001. British Archaeological Reports International Series 986. Archaeopress/John & Erica Hedges, Oxford. Pp. vii + 256, 125 figs., 14 plates. £48. ISBN 1-84171-190

Only a few years ago Near Eastern archaeologists thought we knew with certainty when the first plants were domesticated and how they impacted settled life. In recent years, new archaeological research in eastern Turkey, Jordan, and along the dam-threatened banks of the Euphrates has opened a new window on the early Holocene sedentary cultures, demonstrating the existence of a rich symbolic and social life. At the same time, new archaeobotanical research has brought us sobering recognition of problematic assumptions in recognizing the earliest domesticates and in interpreting ancient economies. Sue Colledge's book offers an important reassessment of existing data and assumptions, an exciting new approach, new data, and highly significant conclusions on the development of the earliest agricultural practices in the ancient Near East.

Colledge's book is a revised and carefully edited publication of her important 1994 doctoral dissertation. As is typical of her previous published work, this book reaches the highest standards of archaeobotanical research. Although some of her major conclusions have been published elsewhere, this volume now serves as an accessible source for her data and extensive statistical analysis of plant remains from a suite of epipaleolithic and early neolithic sites in the Levant. After a brief introduction to contemporary environments, paleoenvironmental reconstruction, chronological periods and subsistence economies that marked different periods (Chapter 1), Colledge reviews the current debates on taphonomy that have so shaken archaeobotanical reconstruction of subsistence and plant economies (Chapter 2). To this debate, Colledge sheds new light on the ethnography of hunter-forager campsites and suggests interesting approaches for recognizing early agriculture through weedy rather than domesticated taxa. In Chapter 3, she provides details of site archaeology for each of the nine Jordanian and five Syrian sites included in the analysis. In a chapter explaining the methods of sampling and analysis, Colledge provides details of the inevitable discrepancies among sites, excavation strategies, assemblage sizes, and identification criteria (Appendix 1) when using samples acquired from different research projects. Her own collections include 145 samples from Jordanian sites, to which she has added the results of van Zeist's and Bakker-Heeres' well-published Syrian collections. To my knowledge, the resulting study of 390 samples from fourteen sites is the broadest study of its kind in the Near East.

In the analysis, Colledge uses basic exploratory statistics such as density indices to assess taphonomic differences among samples (Chapter 5). While she readily admits some limitations to these methods—for example one cannot always know whether pre- or post-depositional activities account for differences—her guesses are reasonably constructed based on ecological context and forager mobility. In Chapter 6 the reader learns what the presence of particular taxa, especially edible grains, nuts, and tubers, means in terms of diet, seasonality, and the spread of agriculture over time and space. The truly innovative core of this volume, however, is Colledge's exploration of taphonomic composition of weedy taxa (excluding cereals) in Chapter 7. Here she uses correspondence analysis to explore how landscapes and resources were exploited. Her efficient text surely disguises many hours of painstaking exploratory trials, the results of which clearly demonstrate influences of geography and chronology on weedy associations. The statistical arguments are easy to follow. Through Colledge's exciting analyses, one can actually recognize the evolution of weed floras through the neolithic and identify the first areas of cultivation. Colledge draws compelling conclusions about the earliest locations of cultivated fields in wetlands adjacent to sites and the expansion of cultivation to other habitats as occupation continued.

There is little that detracts from this volume. It is most likely to interest a special audience of archaeobotanists, but its conclusions are important for any scholar of agricultural origins. Unfortunately Colledge omits the bolder statement her work deserves, for this analysis represents a real breakthrough in tracing the early development of agricultural practices. The editing seems flawless (atypical of BAR volumes) with accurate correspondence between text and figures, although it is somewhat frustrating that figures appear at the end of each chapter. In short, this seems an overly modest summary of highly significant work.

In short, *Plant Exploitation on Epipalaeolithic and Early Neolithic Sites* makes several very important points. First, (and buried in Chapter 6) one finds the earliest morphological domesticated glume wheat (emmer or einkorn) at the Jordanian site of Iraq ed-Dubb. Colledge rightly warns us about chronological implications of a single radiocarbon date. Nevertheless, the fifty-three fragments of diagnostic einkorn/emmer chaff from epipaleolithic and earliest neolithic contexts (pp. 153, 150) provide some of the most convincing evidence to date of a domesticated cereal at about 10,000 BP.

Second, the analytical techniques offer exciting new prospects. Colledge's work puts correspondence analysis at center stage in the statistical exploration of data. The approach is relatively new, especially in the Near East, and very appropriate for large data sets with many "missing" variables (zero occurrence of taxa) so typical in archaeobotany. Such data tend to be non-normally distributed, making the application of many statistical methods unreliable. Furthermore, by assigning ecological and economic codes to variables, Colledge has admirably succeeded in making her data reveal important patterns.

Finally, the results provide a wonderful breakthrough on the earliest development of agriculture. This analysis supercedes typical "origins of agriculture" studies about where and when people started to cultivate and domesticate plants. Colledge has been able to use archaeobotanical data to demonstrate cultivation practices and changes in practice, bolstering a hitherto speculative argument about which ecological habitats were first used and manipulated for planting and tending crops. Specifically, this study provides strong evidence for the long-held supposition that people used floodwater and high groundwater in seasonally inundated lands to grow crops adjacent to the earliest sites. The ramifications of such conclusions await further study, but the analysis presented here will surely occupy an important place in the history of agricultural origins.

Joy McCorriston
Department of Anthropology
The Ohio State University
Columbus, OH 43210-1364

The Mammals of Ancient Egypt. Dale J. Osborn and Jana Osbornova. The Natural History of Egypt: Vol. IV. 1998. Aris & Phillips Ltd., Warminster, England. Pp. 224. $75.00 (paper). ISBN 0-85668-510-0

This is the fourth volume of Aris and Phillips' *The Natural History of Egypt*. The volume synthesizes information from mammalogy, ecology, Egyptology, and archaeozoology to provide a comprehensive summary of our present knowledge of the mammalian taxa. Osborn is a mammalogist and systematic zoologist who co-authored *The Contemporary Land Mammals of Egypt,* the widely respected publication series of the Field Museum of Natural History. Although neither author is an Egyptologist, they have thoroughly researched the Egyptological literature. The result is a very strong effort and the best text of the series.

The discussion of each taxon begins with a segment on nomenclature. This is an important contribution in itself because significant confusion exists in the Egyptological literature over the names of various taxa. This volume establishes the nomenclature for the taxa of mammals known from ancient and contemporary Egypt, and, while minor disagreements still remain (e.g., *Dama dama* Brooke or *Dama mesopotamica* L.?), it provides the scientific and common names that should be used in future publications.

Following each nomenclature segment is a description of the taxon. These descriptions form the basis of the authors' identifications and inform their critique of identifications made by previous authors of the taxa in rock carvings, tomb and temple representations, and sculptures. Although arguments in the literature concerning the identification of mammalian representation in the art of ancient Egypt are profuse, Osborn and Osbornova's detailed discussions and expertise inspire a rare sense of confidence in the reader. Only a handful of identifications (e.g., the representations of the oryx, gazelle, and of one feline) may arouse some skepticism.

The discussion on the various breeds of dogs and their artistic representation is fascinating and particularly useful. The treatment of the relationship between the shrew and the ichneumon in ancient Egypt mythology is intriguing. It leads the authors to suggest that confusion in identifying sculptures of the shrew and ichneumon may result from the purposeful blurring of the differences between the two taxa by the sculptors. Perhaps the most entertaining section is entitled "Errors and Discrepancies." In this section the authors catalogue misidentifications and errors in nomenclature in the literature. The longest list is for the oryx, but the errors and discrepancies for the canids, particularly the domestic dogs, are the most useful and interesting.

While the book is well conceived and certainly well written, a number of small irritating problems stand out. The nomenclature discussions, although valuable as a whole, are very variable in detail. Some include short explanations for the etymology of the scientific names while others do not. The sections dealing with the natural history of each taxon are also variable in quality. Descriptions of the environments in which the taxa might have occurred in ancient Egypt are frequently omitted. In the discussion of the fallow deer (*Dama mesopotamica*), for example, it would have been useful to point out that the deer inhabited thickly wooded areas along the edges of the Nile Valley, thus making the early disappearance of this taxon more understandable. The layout of figures within the text is often clumsy and forces the reader to shift back and forth between pages. The worst example of this miscue is the location of the identifications of animals in Table 1, which is located at the end of the chapter some twelve pages later. The discussion of lion manes (p. 114) is also confusing. Two 1996 articles by Houlihan are cited, yet, since they lack further differentiation in the text [i.e., Houlihan (a) v. Houlihan (b)] it is difficult to tell which reference is being cited.

With the exception of these minor errors, this is an outstanding text. The volume synthesizes an impressive amount of information from at least four sometimes-disparate disciplines. What makes such a synthesis such a valuable resource is the comprehensive literature review coupled with flashes of insight. Given these criteria, this is an extremely valuable resource for anyone working with mammals in ancient Egypt. It belongs on the shelf of every archaeozoologist working in North Africa and the Middle East and most certainly on the bookshelf of every Egyptologist.

Richard W. Redding
Museum of Anthropology
University of Michigan
Ann Arbor, MI 48109

American Bamboos. Emmet J. Judziewicz, Lynn G. Clark, Ximena Londoño, and Margaret J. Stern. 1999. Smithsonian Institution Press, Washington D.C. and London. Pp. 392. $49.95 (hardcover). ISBN 1-56098-569-0

The histories of humans and the bamboos have pushed and pulled at one another for thousands of years. Bamboo tends to provoke deep-seated responses from people in North America because it is invasive, quick growing, and, perhaps above all, *eastern.* Many non-scientists are frequently stunned to learn that bamboos are even native to the western hemisphere, never mind that the number of New World bamboos rivals that of the Old. As this text is very accessible to anyone equipped with some basic understanding of the natural sciences, it will hopefully dispel some of these false impressions. More importantly, the book somehow manages to be accessible to more general audiences while being extremely detailed, insightful, and useful for the most accomplished botanist. Such a combination is rare.

A key to the American bamboos and basal grasses follows five chapters of text. These chapters, in just 134 pages, cover bamboo anatomy, bamboo in the American landscape, the use of American bamboos by people, the techniques of growing bamboo, and recent and historical thought on the definitional characteristics of bamboo. Accompanying the chapters and scientific key are over 200 color photographs, maps, and drawings of the highest quality. Four appendices cover the themes of the geographical distribution of the bamboo genera, avian specialists of understory bamboos, bamboo common names, and commonly cultivated bamboos in the United States and Europe. A glossary, particularly useful for newcomers to dimorphic key reading, completes the text.

Bamboo anatomy can be a bewildering subject; yet, understanding the anatomy of this unique plant group is critical to understanding its evolutionary significance, taxonomy, and human use. The authors painstakingly walk the reader from node to internode, from root to culm, and from flower to seedling with exceptional grace, and they provide boldface type for important terms, detailed anatomical sketches, schematic views of habits, and even scanning electron micrographs in accompaniment. For some, the treatment of bamboo anatomy may be a bit too detailed, but those who proceed patiently through the chapter will be rewarded with a true breadth of understanding. For many, in fact, this may be the most useful and relevant of all chapters.

Chapters 2, 3, and 4 are easier reads, but no less brilliant. "Bamboos in Native Landscapes" provides extraordinary detail of the subject matter, in a way that could only come from decades of fieldwork and an incredible handle on the available literature. Although the entire text will be of use to the ethnobiologist, the third chapter on the human use of bamboo is obviously the most relevant for readers of the *Journal of Ethnobiology.* The thematic and chronological categorizing and describing of human uses of bamboo provides an excellent introduction. More detail on these topics is somewhat wanting, but, considering the overall breadth of the text, the coverage is reasonable. The discussion of the use of *Guadua angustifolia* Kunth in construction among the peoples of western Colombia and Ecuador is particularly well informed. The fourth chapter, on cultivating bamboos, is a logical development of Chapter 3 and captures the interest of an entirely new audience. Although just fifteen pages in length, the chapter does an excellent job summarizing the methods of cultivation. The authors' treatment of evolution, cladistics, and bamboo phylogeny is superb and insightful and summarizes and extrapolates on the findings of many authors; notable among these is Lynn Clark.

The 200-page key is in some ways the climax of the text, where the first four chapters provide the tools and background for the key to be useful and meaningful. Each genus is treated with great detail, plus a distribution map and a color photo of a representative species. One will quickly notice that Judziewicz, Clark, Londoño, and Stern frequently appear as plant authors, which reflects their substantive contribution to the study of bamboo and the reliability of this volume.

American Bamboos is a remarkable achievement. Although some themes could and perhaps will be treated as texts themselves, the book will certainly inspire many future bamboo enthusiasts as it has done with this reviewer. The book belongs in the personal library of every ethnobotanist or ethnobiologist, novice or expert bamboo gardener, landscape restorationist, and evolutionary biologist. In the acknowledgments, the authors express their wish to have followed in the footsteps of the great American bamboo experts—the Floyd McClures, Cleo Calderóns, and Thomas Soderstroms of the world—and without a doubt they have done so.

Darron Collins
Latin American and Caribbean Secretariat
World Wildlife Fund
Washington, DC 20037-1132

A Plague of Rats and Rubbervines: The Growing Threat of Species Invasions. Yvonne Baskin. 2002. Island Press, Washington. Pp. vii + 377; photographs, appendices, notes, index. $25.00 (hardcover). ISBN 1-55963-876-1

Non-indigenous species can cause great economic damage, irreversible ecological changes, and significant public health impacts. Executive Order 13112 of 1999, which established the National Invasive Species Council, has placed invasive species issues firmly on the United States' domestic policy agenda. In addition, invasive species have been elevated to the international trade and environmental policy agendas through a variety of international agreements, particularly the World Trade Organization's (WTO) Sanitary and Phytosanitary Agreement (SPS). The National Research Council of the National Academy of Sciences (U.S.A.) (2002) has recently published a volume on invasions of non-indigenous plants and plant pests. International non-governmental scientific organizations like the Scientific Committee on Problems of the Environment (SCOPE) have also made invasive species a priority. Baskin's book had its origins in the desire of SCOPE's Global Invasive Species Programme (GISP) to produce a volume that could communicate these issues to the broadest possible audience.

The aim of the book, then, is to provide a fresh, comprehensive, and accessible view of the problems of invasive species. Specifically, Baskin emphasizes the global scope of invasive species problems—especially in relation to global trade—and devotes considerable space to the search for creative means of interdiction and control of non-indigenous species. The book is intended for a very broad, non-specialist audience.

The book's coverage is quite comprehensive, including chapters on the history of invasive species worldwide, agricultural pests, impacts of invasive species on biodiversity and the environment, and global trade. For a general audience, Chapter 6 is a particularly good review of recent research on predicting invasiveness from species and habitat traits. There are also chapters on quarantine and interdiction in relation to trade, and case studies of control efforts in New Zealand, Australia, South Africa, and the Galápagos Islands. The book closes with a sound set of policy and action recommendations.

Overall, the book achieves its desired aim, though whether it inspires the action it promotes will remain to be seen. Certainly the book is well written and engaging, and is very appropriate for its intended audience. Baskin's liberal use of anecdotes and quotes from interviews enhances the book's appeal to a general audience. As far as teaching is concerned, the whole book might be usable for an honors non-majors' environmental science course or an undergraduate topics course (with supplemental readings from the primary literature). Portions of the text would also be suitable as assigned readings in a wide array of courses, especially Chapter 6.

REFERENCE CITED

National Research Council. 2002. *Predicting Invasions of Nonindigenous Plants and Plant Pests.* National Research Council, Committee on the Scientific Basis for Predicting the Invasive Potential of Nonindigenous Plants and Plant Pests in the United States. National Academy Press, Washington, D.C.

Mark C. Andersen
Department of Fishery and Wildlife Sciences
New Mexico State University
Las Cruces, NM 88003-0003

Biodiversity and Traditional Knowledge: Equitable Partnerships in Practice. Sarah A. Laird (ed.). 2002. People and Plants Conservation Series. Earthscan Publications, Ltd., London. Pp. 288. $40.00 (paper). ISBN 1-85383-698-2

The primary aim of this outstanding book is to provide a broad overview, synthesis, and open discussion of practices and processes concerning fairness and equitable partnerships between north and south in biodiversity research and bioprospecting. The book is primarily oriented toward the applied social and natural scientists. The authors stress the need for addressing the practical use of concepts of equity developed in recent years and understanding the dynamic, rapidly changing contexts in which these concepts continue to evolve. The authors do not downplay the complexity of the issues.

The authors address questions such as: "What does equity mean?" and "How is equity practiced?" It is not an instruction manual, but rather a synthesis of information for informed experimentation, planning, and learning by stakeholders involved in the practice of ethnobiology. The chapters consistently provide well-written, balanced perspectives with thorough discussion of the issues, and they demonstrate a fine-tuned development of ideas. Clarity of expression and the use of well-defined policy terminology make the book accessible to a wide range of readers. It provides in-depth analysis of the complexities and challenges of globalization, intellectual property rights, and benefit sharing, yet the tone remains hopeful at a time when some are exiting the bioprospecting field in frustration.

The section on biodiversity research relationships—the longest in the book—lays the foundation for much of what follows. It covers topics such as codes of ethics, research guidelines, examples of policies, publication issues, balancing concerns, and "giving back" guidelines. The section emphasizes the need for biodiversity researchers and bioprospectors to re-evaluate their assumptions and ethical standards and to participate in the creation of national and international policy. Many sidebars and case studies from a diverse set of institutions flesh out the section very well, while real life discussions of experiences by field researchers, such as William Milliken, greatly enrich the usefulness and liveliness of the text.

The section on research and prospecting in protected areas examines the issue of how research programs can be integrated with and complement local informational needs. There is excellent and insightful advice for protected areas managers and other relevant decision makers. A section on commercial uses of biodiversity features interesting and useful information on the value of biodiversity, much of which will be familiar to readers of the previous book by Laird and Kate (2000) on commercial uses of biodiversity.

The book also includes useful information on core elements of equitable research relationships, the need for written research agreements, contracts, trust funds, international agreements, and the development of national policy.

This book is eminently practical and succeeds in its intended purposes. It treats the subject matter with holism, with not-overly-specialized text, and with specific examples and case studies that make it interesting and informative. The overall excellence of the book makes it difficult to criticize, but a bit more advice for indigenous peoples interested in learning how to write their own agreements would certainly have been a useful addition.

Biodiversity and Traditional Knowledge is an excellent work that should be required reading for everyone involved in these fascinating and complex issues.

REFERENCE CITED

Laird, Sarah A. and Kerry Ten Kate, eds. 2000. *The Commercial Use of Biodiversity: Access to Genetic Resources and Benefit-Sharing.* Earthscan Publications, London.

Mark Plotkin
Amazon Conservation Team
Arlington, VA 22209

Darron Collins
Book Review editor

Journal of Ethnobiology 22(2): 315–316 Winter 2002

Announcement

Society of Ethnobiology

26th Annual Conference
Ethnobiology and Sustainability

University of Washington, Seattle
March 26–29, 2003

The Society of Ethnobiology is now accepting abstracts for its 26th annual conference in Seattle at the University of Washington's Center for Urban Horticulture. The Society last met here in 1984. Seattle is on a wedge of land between Puget Sound and Lake Washington, encircled by snow peaks of the Olympics and Cascades. On a clear day (there is a chance) the volcanic peaks march past from Baker to Rainier (aka *Tahoma*). Seattle is the namesake of a Duwamish chief. His spirit haunts us still. The University of Washington is an elegant campus. The cherries on the quad will be in full bloom. The University is well known for its outstanding Environmental Anthropology program, schools of forestry and marine affairs, and the Burke Museum—featuring at this time a new exhibit: Out of the Silence: The Enduring Power of Totem Poles—venue for our conference banquet. Our conveniently located conference venue is the Center for Urban Horticulture, known for cutting-edge research in ecological restoration.

Keynote speaker: Dr. Fikret Berkes, author of *Sacred Ecology,* Professor, Natural Resources Institute, University of Manitoba, Canada Research Chair

Program

Wed. March 26	Registration and evening welcoming reception.
Thurs. March 27	Formal welcome by Duwamish tribal representatives Paper and poster sessions Evening keynote address by Dr. Berkes
Fri. March 28	Paper and poster sessions Tour of the exhibit: *Out of the Silence: The Enduring Power of Totem Poles* Evening banquet at the Burke Museum, including awards ceremony and entertainment
Sat. March 29	Field trips: One-day and overnight trips
Sun. March 30	Overnight field trips conclude.

Paper/Poster Submissions: This year's conference theme is *Ethnobiology and Sustainability*. We encourage submissions relevant to that theme, or of general ethnobiological interest. Members must submit their title and abstract, along with the registration fee and accompanying proposal form to Eugene Hunn by February 14, 2003. If a special session is planned, the organizer should contact Hunn by February 1 with a proposal including a thematic description and a list of likely participants with titles.

Registration: Advanced registration is $70. Student advanced registration is $45. The late registration fee (after February 14) is $90, $55 for students. (New members may register *and* join the Society at a bargain rate of $100.) The registration fee covers all events except the field trips and banquet, including a tour of the Burke Museum on Friday evening preceding the banquet. Please download forms from the Society's website online at: http://www.ethnobiology.org.

Field trips: One-day field trips, Saturday, March 29, are planned to points of interest in and near Seattle, the Cedar River watershed, and the Skokomish Indian Reservation. Over-night field trips TBA. Details will be posted on the Society's website at: http://ethnobiology.org.

Accommodations: See our website.

Websites: Society of Ethnobiology: http://ethnobiology.org; University of Washington, Seattle: http://www.washington.edu/

For Further Information contact Conference Organizer Eugene Hunn, Department of Anthropology, Box 353100, University of Washington, Seattle, WA 98195–3100, USA, hunn@u.washington.edu.