Journal of Ethnobiology 24(2): 173–201 Fall/Winter 2004

SUBTLE AND PROFOUND SENSORY ATTRIBUTES OF MEDICINAL PLANTS AMONG THE KENYAH LEPPO' KE OF EAST KALIMANTAN, BORNEO

LISA X GOLLIN
Division of Ecology and Health, John A. Burns School of Medicine
University of Hawai'i, Honolulu, HI, 96822-2319
<lxgollin@hawaii.edu>

ABSTRACT.—The Kenyah Leppo' Ke of Borneo rely heavily on plants grown and gathered for healing a wide range of ailments. This study explores sensory selection criteria of medicinal plants in regard to cultural understandings of efficacy. Over 92% of the medicinal plants have one or more salient sensory properties such as bitterness and astringency. Some Leppo' Ke sensory attributes have no simple English gloss; "***nglidah***," which characterizes disparate species (e.g., a moth larva, *Cymbopogon citratus, Litsea cubeba*), is discussed. This sensory category shares a number of chemotaxonomic and pharmacologic characteristics. Subordinate categories of the Kenyah sensory domain accentuate the subtleties and sophistication of perception, interpretation, and application that guide their therapeutic systems. The chemistry of less obvious sensory attributes and implications of this research for ethnobotany concludes this paper.

Key words: Borneo, chemosensory evaluation, ethnobotany, ethnopharmacology, ethnomedicine.

RESUMEN.—Los Kenyah Leppo' Ke de Borneo dependen básicamente del cultivo y recolección de plantas para curar un amplio rango de enfermedades. Este estudio explora los criterios sensoriales de selección de plantas medicinales y su relación con el entendimiento cultural sobre su eficacia. Se ha encontrado que más del 92% de la flora medicinal tiene una o más propiedades sensoriales sobresalientes como el amargor y la astringencia. Algunas categorías sensoriales usadas por los Leppo' Ke, no tienen traducciones simples o convencionales al inglés. En el trabajo se analiza la cualidad "nglidah," que caracteriza a una dispar serie de especies: desde una larva de polilla, hasta *Cymbopogon citratus*, y *Litsea cubeba*. Esta categoría sensorial comparte tanto atributos químico-taxonómicos como farmacológicos. Las categorías subordinadas del dominio de los sentidos de los Kenyah, enfatizan la precisión y sofisticación de la percepción, interpretación y aplicación que guían los sistemas terapéuticos nativos. El documento concluye discutiendo la química de los atributos sensoriales menos obvios y las implicaciones de esta investigación para la etnobotánica.

RÉSUMÉ.—Les Kenyah Leppo' Ke de Bornéo utilisent les plantes tant cultivées que récoltées afin de guérir un vaste ensemble de maladies. Cette étude examine la compréhension culturelle de l'efficacité des plantes médicinales en faisant appel à une série de critères sensoriels de sélection liés à ces plantes. Plus de 92% des plantes médicinales possèdent une ou plusieurs propriétés sensorielles importantes telles que l'amertume et l'astringence. Parmi les attributs sensoriels des Leppo' Ke, certains ne peuvent être traduits en anglais en des termes simples.

Ainsi, le «**nglidah**», qui caractérise plusieurs espèces disparates (par exemple, des larves de papillon de nuit, *Cymbopogon citratus, Litsea cubeba*), est discuté dans cet article. Cette catégorie sensorielle possède plusieurs caractéristiques pharmacologiques et chémotaxonomiques. La présence de catégories subordonnées liées au domaine sensoriel des Kenyah augmente les subtilités et la sophistication non seulement de la perception, mais également de l'interprétation et de l'application qui servent de guide dans leurs systèmes thérapeutiques. La chimie des attributs moins frappants sur le plan sensoriel ainsi que les conséquences de cette recherche pour l'ethnobotanique complètent cet article.

INTRODUCTION: WAKE UP AND SENSE THE MEDICINE

A growing number of ethnobotanists and ethnopharmacologists have shown that sensory perception plays a major role in how humans identify and utilize medicinal plants (e.g., Berlin and Berlin 1996; Brett 1994; Brett and Heinrich 1998; Casagrande 2001; Heinrich 1994, 1998; Heinrich and Barrera 1992; Johns 1990; Leonti et al. 2002; Shepard 1999, 2002). They have demonstrated that chemosensory input is cognitively structured, named, and assigned a therapeutic use value. These investigations have improved our understanding of the cultural and chemical basis for the use of medicinal plants by indigenous and native peoples, and, for this author are inspirational.

Whereas visual evaluation of the floral environment is the most obvious cue by which people determine a plant's utility for medicine, this paper centers on chemosensory selection criteria for medicinal plants. After several ethnobotanical field investigations around Indonesia over the course of more than a decade, it became clear to me that native plant practitioners place a high value on certain sensory features of plants in selecting, organizing, and employing their botanical pharmacopoeia. I realized that if chemical cues such as bitterness, astringency, and irritant properties are salient in the immensely popular and increasingly prepackaged system of Javanese *jamu* found throughout the archipelago (see Gollin 1993), this must also be true in the more localized medical systems still reliant on the collection of fresh material. This assumption was supported by investigations I conducted in Sumatra (Gollin 1991) and Maluku (Etkin et al. 1996) and in my initial research in Kalimantan (Gollin 1997a, 1997b). When walking through the woods with plant consultants in Kalimantan, I noticed that people frequently snapped off leaves and put them to tongue or nose. They also used a machete to nick a tree to take a swipe of the latex or to examine the inner bark or xylem. Often, inspecting the plant's odor, taste, and morphology is done for the specific purpose of identifying a plant or determining a plant's medicinal or other value. But at times it appears to be almost a behavioral tic, a habitual assessment of one's surroundings. In and around the village and in fields where the plants are more familiar, people do not conduct this diagnostic. However, as is true across Indonesia, people in Kalimantan discuss and order plants according to essential properties such as bitterness, astringency, and pungency. Considering the wealth of literature on Indo-Malaysian medicinal folkways, it is odd that only a few authors have touched upon the sensory aspects of medicinal plant use; those that

have done so have treated the subject lightly (e.g., Ave and Suruto 1990; Kimball 1979; van Esterik 1988).

Perceptual Salience of Bitterness and Astringency among Both Native Plant Practitioners and Ethnobotanical Researchers.—Bitter and astringent principles are especially salient to plant users and are heavily featured in pharmacopoeia worldwide. This is not surprising, because there is a link between chemoperception and biological activity (Gollin 2001).

The understanding that bitter principles are therapeutic is widespread in native healing systems and foodways (Etkin et al. 1990; Etkin and Ross 1982; Johns 1990, 1994). One pattern found in diverse settings is the application of bitter principles for treatment of internal (primarily fever, gastrointestinal, and respiratory complaints) and external infections (skin ailments). Bitter plants are employed against gastrointestinal complaints among the Tzeltal and Maya of Chiapas (Berlin and Berlin 1996; Brett 1994), the Mixe of Oaxaca (Heinrich and Barrera 1992), the Matisigenka of Peruvian Amazon (Shepard 1999), the Alune of Maluku (Etkin et al. 1996), and the Popoluca of Mexico (Leonti et al. 2002). Bitter principles are valued as antipyretics in diverse locales from South America (Johns 1990) to Thailand (Brun and Schumacher 1987). In every locale in which I have conducted research around Indonesia, I have been told by plant users that bitterness cures fever, particularly malaria. For instance, for the Alune of Maluku, bitterness is said to strengthen the blood and is favored for treatment of febrile conditions (Etkin et al. 1996).

The therapeutic attributes of astringency are especially similar across cultures. The physiological effect of astringency—due to the presence of polyphenolic compounds, or tannins (Cotton 1996)—is so distinctive that it is easy to see why the therapeutic intentions stated by native practitioners for tannin-containing plants is similar in diverse medical systems. Tannins blur the distinction between a chemical sense and a tactile one. In other words, astringency is as much the sensation of drying and roughness in the mouth, and the drawing-in sensations felt in the cheeks and muscles of the face, or the feeling of tightening and drying of the skin from external applications, as it is a flavor (Lawless and Heymann 1999). Astringent plants are exploited widely by humans for stomach disorders, most prominently as treatment for diarrhea and dysentery (Berlin and Berlin 1996; Brett 1994; de Padua et al. 1999; Etkin et al. 1996; Heinrich and Barrera 1992; Leonti et al. 2002; Shepard 1999), styptics and vulneraries (de Padua et al. 1999; Perry and Metzger 1980), and control of dental caries (de Padua et al. 1999; Elvin-Lewis et al. 1980; Kakiuchi et al. 1986; Perry and Metzger 1980). For instance, among the Matsigenka, astringent plants are believed to draw the invisible worms that cause illness "together" so that they can be expelled from the body (Shepard 1999). These beliefs parallel perceptions about astringency in Indo-Malaysia. Among the Alune astringent plants are understood to expel "dirt" and "clean the stomach" and are therefore useful for diarrheal diseases, as well as cleaning and shrinking the uterus after childbirth (Etkin et al. 1996).

It is no longer novel to argue that people utilize bitter and astringent (and related pungent) properties in plants to banish disease according to familiar patterns. Moreover, there is by now an immense corpus of information based on

laboratory and clinical analysis that confirms efficacy from a scientific standpoint (e.g., Ross 1999). Although beyond the scope of this article, it is worth noting that pharmacologic analysis of plant remedies underscores their effectiveness against certain ailments.

Scientific experiments conducted on bitter and astringent plants have also demonstrated the degree to which a given taxon produces the effects desired and expected *within the user's own system of medical belief and practice*. Efficacy is itself a cultural construction (Etkin 1992; Ortiz de Montellano 1986). For instance, bitter plants sometimes contain powerful emetic and diaphoretic alkaloids, properties that often constitute the indigenous rationale for a plant's use. *Eurycoma longifolia* Jack is a highly regarded febrifuge and treatment for stomachache throughout Borneo and other regions of Indonesia (Perry and Metzger 1980). The bitter constituents of the roots are strong enough to induce vomiting in large doses and are expressly employed for their emetic effect in order to expel disease from the body (Sosef and Horsten 1999).

Expanding the Ethnopharmacological Palate.—Sense properties such as bitterness, astringency, pungency, sourness, and sweetness are consistently linked to the treatment of specific classes of disease. These "basic" or "primary" tastes found in folk classification systems depart slightly from those recognized in Western science. Western taste-researchers since Aristotle generally agree that there are four basic qualities: sweetness, bitterness, saltiness, sourness that combine to make all known flavors (Scott and Plata-Salaman 1991). Recently, a new taste primary—long recognized in Asian systems—was added to the traditional Western scientific quartet, *umami* (Japanese for foods with a savory, delicious, meaty essence) as elicited by monosodium glutamate (Lindemann 2000). The gustatory dimension is vital to insight into most Asian therapeutic systems (Laderman 1983; van Esterik 1988). For instance, in the royal medical tradition of Wat Pho, Thailand, taste theory (*rod*) postulated curative properties for each of ten plant flavors used as medicines and foods; e.g., astringency "heals wounds," sweetness "permeates the flesh," bitterness "supports the blood and the bile," heat "cures wind," fat "cures muscles and tendons," salt "permeates the skin," sour "bites the mucus," bland "cures mucus and is diuretic" (Brun and Schumacher 1987: 22–23). Hindi taste vocabulary is made up of six basic "tastes" (*rasa*): sweet, sour, salty, bitter, pungent, and astringent that form the basis of Ayurvedic medical theory (Pinard 1991).

Previous scholarship on the taste, smell, and feel of medicinal plants has primarily been conducted in South and Central America. The research presented here focuses on chemosensory selection and utilization of medicinal plants among the Kenyah Leppo' Ke people of East Kalimantan, Indonesian Borneo. Local interpreters recognize in the vast majority (92%) of species that make up the Leppo' Ke botanical pharmacopoeia one or more sensory properties. Often sensory features of plants are explicitly linked to remedying broad illness categories (e.g., bitter plants for fever conditions) or to specified therapeutic mechanisms (e.g., astringent plants for stanching blood flow). This ethnobotanical line of inquiry will go a step further than other investigations that have concentrated on a handful of more obvious organoleptic characteristics of medicinal plants by high-

lighting subtle sensory properties of therapeutic significance as identified by the Kenyah Leppo` Ke, with special attention to the complex culinary and therapeutic quality, ***nglidah***.

STUDY SITE

The Bahau River Valley is in the Pujungan subdistrict of East Kalimantan, central Borneo. The Bahau watershed is one of the largest expanses of continuous forest in Borneo (Wollenberg 2001). The villages visited for this study sit near or within the boundaries of the Kayan-Mentarang National Park, one of the largest protected blocks of rain forest in Southeast Asia (Jessup et al. 1992). The region is very mountainous and steep (few slopes are less than 40%) (Snel 1994) and holds a complex mosaic of vegetation types (MacDonald 1993) as well as a high proportion of species endemism (Jessup et al. 1992). Lowland forests (below 1,000 mASL) include varied species of dipterocarps (especially *Shorea* and *Dipterocarpus*), Euphorbiaceae, Moraceae, and Dillinaceae, among others. At around 400 mASL, mixed dipterocarp forest changes quite abruptly to mixed primary oak forest, and is dominated by *Lithocarpus, Castanopsis,* and *Quercus.* In the upper plateaus there are a number of edible and other useful plants such as *Salacca, Artocarpus, Calamus,* and *Garcinia* (Sorenson and Morris 1997). Forest trees are covered with a variety of epiphytes and lianas. The human population density is low, with less than one person per square kilometer throughout the region (Jessup et al. 1992).

Research was conducted primarily in the Upper Bahau village of Long Tebulo, but also in neighboring settlements of Long Pujungan (pop. 427), Long Alango (pop. 406), Long Kemuat (pop. 100), and Apau Ping (pop. 346). I chose Long Tebulo as the primary study site because the residents showed a deep knowledge of and interest in plants. Tebulo has no government health post, and Tebulo respondents were able to free list more medicinal plants than those from neighboring villages. Tebulo has a substantial number of elders, who are generally repositories of extensive ethnobotanical knowledge. Most importantly, Tebulo residents welcomed the opportunity to record the Kenyah medicinal flora and local use of plant medicines (Figure 1).

Long Tebulo is situated at a bend on the upper reaches of the Bahau River (lat. 2.5° N, long. 115.5° E). The village is approximately 375 m above sea level, while the entire village territory extends several hundred meters up to and beyond the surrounding mountain ridges. The term ***long*** means "confluence." The village is bisected by Sungai Tebulo, a small river which drains into the Bahau. The ***tana` ulen*** 'reserved/restricted land'—the customary village territory of Long Tebulo—is partly located within the boundaries of the Kayan-Mentarang National Park, which is across the river from the village. The closest neighboring villages are Long Alango (two hours upriver) and Long Uli (an hour downriver). Tebulo has a church, an elementary school, a meeting hall, and soccer field. In addition to a pastor and church officials, there are a few civil servants: two teachers, a village head and village secretary.

Long Tebulo had a population of 165 people at last count (Gollin 2001). The number of residents actually present in the village at any given time is variable.

FIGURE 1.—Author's research associate, Ba`un Uluk, and a focus group of men from Long Tebulo resting in the forest before collecting medicinal plants.

There is regular out-migration to Malaysia in search of temporary wage-labor employment, while students who attend junior (SMP) and senior (SMA) high schools in Pujungan and Tanjung Selor come and go according to the academic calendar. Kenyah Leppo` Ke represents the majority cultural group in Tebulo. There are also Kenyah Leppo` Ma`ut (14), Kenyah Bakung (5), Kayan (5), and Kenyah Leppo` Tau (1) residents. The Kenyah, one of the most numerous and heterogeneous groups of Dayak (an exonym used to describe the numerous indigenous tribes that inhabit the Borneo interior), are comprised of over forty different subgroups with different dialects and cultures (Anau 1998).

The landscape around Long Tebulo is highly anthropogenic. A walk from village to forest reveals a carefully designed resource schema, with a rich array of plants grown or managed for convenient access to foods, medicines, and building and craft supplies. Yard gardens hold many taxa. Trails radiating out of the village to the lowland wet rice (cf. *Oryza sativa* L.) fields and the upland swidden fields are lined with pineapples (*Ananas comosus* Merrill), fruit trees (e.g., *Lansium domesticum* Jack), manioc (*Manihot esculenta* Crantz), and plants such as bamboo and *Donax cannaeformis* Rolfe used for plaiting, foods, and medicines. Taro (*Colocasia esculenta* Schott) and water spinach (*Ipomoea aquatica* Forsk.) are planted in the canals that fill the terraced paddy fields. Secondary forest close to the village provides firewood, fruit, and the largest percentage of medicinal flora. Further from the village in primary forest areas, families tend trees to which they hold usufruct rights such as durian (*Durio* spp.) (Figure 2).

FIGURE 2.—Oko But demonstrates how to blow water through the internodes of ***bulo apai*** (*Dinochloa* sp.), a bamboo used as a source of potable water on forest sojourns, and as an eye wash for ocular irritation. ***Bulo apai*** is one of the few remedies in the Leppo' Ke pharmacopoeia with no explicit sensory property.

METHODS

Field research in Kalimantan was carried out in two field seasons for a total period of fourteen months (July–August 1994 and June 1997–June 1998). I initially visited the Upper Bahau in 1994 as a member of an ethnobotanical field team. During this preliminary fieldwork among the Kenyah, I became acquainted with the medicinal flora, diet, health concerns, ethnomedicinal practices, and healing specialists of four Upper Bahau River communities (Gollin 1997a, 1997b). I re-

turned to the area in 1997 to conduct doctoral research. I collected ethnographic data and botanical specimens with the assistance of one of the daughters of my Kenyah host family in Tebulo. We conducted interviews in Indonesian and the local language Kenyah Leppo' Ke and, to a minor extent, Kenyah Leppo' Ma'ut.

Project Participants.—In total, 149 people in 7 different communities (Long Alango, Apau Ping, Long Berini, Long Kemuat, Long Bia', and Tanjung Selor) were formally interviewed for this study, many on a repeated basis. Participants were interviewed individually, during family and community gatherings, and in focus groups defined by age, gender, education, and expertise. I employed (nonrandom) judgment sampling and snowball sampling methods (Bernard 1994). Each time I conducted a set of interviews, particularly cognitive protocols, I used judgment sampling to create a sample representative of the population. This approach enabled me to elicit a diversity of views held by recognized botanical specialists and lay practitioners. Snowball sampling was used to identify villagers recognized as knowledgeable about medicinal plants and other healing therapies (e.g., ***tukang memoh*** 'massage technician/worker') and build a network of practitioners to work with on a regular basis.

Interview Protocols.—Structured, semistructured, and unstructured data collection conducted in peoples' homes and on plant collection field trips centered on three general categories: health and illness beliefs and practices; healing beliefs and practices; and chemosensory and symbolic aspects of therapeutic plants. Different interview techniques and careful field observation were used to collect, contextualize, and confirm data (Bernard 1994; Etkin 1993a; Pelto and Pelto 1990). A variety of research tools such as free listing, pile sorting, and consensus analysis were used to define cultural domains, elicit native taxonomies, determine consensus and variation in knowledge, and continually cross-check impressions and statements with local respondents (Bernard 1994; Handwerker and Borgatti 1998; Romney and D'Andrade 1964; Trotter and Logan 1986; Weller and Romney 1988; Werner and Fenton 1973).

Elicitation of Sensory Properties of Plants and their Medicinal Values.—I elicited sensory information in a context of use, gathering a list over many months before using structured protocols to ask respondents about medicinal and extramedicinal qualities of flavors, textures, and odors (cf. Brett 1994). Taste and smell are richly complex experiences (Rozin 1982) and hence not readily subjected to "standard" measures. Attempts to determine "basic taste terms" employing methodology developed for the color domain (Berlin and Kay 1969) have been problematic (Bartoshuk 1978; Kuipers 1991).

Sentence completion methods were used to elicit and expand data on chemosensory properties of plants. Sensory qualities of ethnobotanical taxa mentioned by respondents repeatedly in interviews, during plant collection trips and cooking, dyeing, or healing sessions were used to construct a list of eighteen of the most salient sensory qualities of plants. Respondents then linked sensory quality with the therapeutic value of a plant by verbally filling in the following Leppo' Ke sentence for each property: "***Buk ka*** (e.g., ***pa' it, pa:t***) ***de, teneng taban***

inu a o?" meaning, "If something (a plant) is ——— (e.g., 'bitter,' 'astringent'), it is good for ——— (disease or medicine)?"

Observation.—Observation of plant selection, preparation and application was essential to separating what people say they do from what they actually do, and for generating more appropriate research questions (Bernard 1994; Martin 1995). For example, in context of use I was able to observe and query practitioners about the role of plants *without* distinctive sense properties that were likely to be biologically inert: are such plants adjuvants (i.e., do they amplify the activity of the main ingredient); are they vehicles (solvents, binders or carriers) for other biologically active medicinal components; do they render unpalatable preparations more palatable or serve a symbolic end? My personal experiences with local remedies for stomachache, fever, wounds, and skin infections and an eye infection aided my understanding of reported therapeutic effects and sensory aspects of the *materia medica*. I kept a weekly log of meals and recipes. I participated in household and community activities such as gathering food plants and fuel wood, fishing, farming, cooking, church raising, and celebrations which deepened my understanding of the role of plants in peoples' daily lives and complemented formal data collection.

Collection, Preparation, and Identification of Botanical Specimens.—My research associate, Ba'un Uluk, and I collected voucher specimens and ethnobotanical data during walks with villagers. Trail walks varying in length from about three to twelve kilometers followed the pathways from the village to wet rice fields (first series of interviews), hilltop rice fields (second series), and finally near and remote forest areas (third series). Almost every adult in Tebulo participated in individual or focus group trips, as did a few plant specialists in the villages of Long Pujungan, Long Alango, and Apau Ping. We were able to cover approximately seventy-five percent of the ***tana' ulen*** familiar to Tebulo villagers. We also collected plants in primary forest area about one hour upriver of Tebulo, an undisturbed site not generally exploited by Tebulo residents. Plant walks would start on a common pathway and end up in a villager's family field or favorite spot for hunting or gathering forest products. Covering the same terrain repeatedly with different participants aided my ability to see consensus and variation in knowledge and ascertain individual expertise. Visiting new areas suggested by a field collaborator allowed him/her to point out the ethnobotanical flora with which s/he was most familiar and extend my knowledge of surrounding habitats. Plant walks and collection trips yielded a number of plants not mentioned during in-house interviews.

Yard, village, field, and forest interviews followed the same line of inquiry as in-house formal and informal surveys. Aspects of the selection, preparation, application, and expected outcome of each medicinal plant encountered were discussed. Forest excursions were especially useful for discussing sensory properties of plants. Other economic flora that intersect with the botanical pharmacopoeia, such as hunting and fishing poisons, cosmetics, dyes, and food plants, were recorded. Field trips also addressed shifting cultivation techniques, forest succession, ethnoecology, and ethnotaxonomy (e.g., local classification of plants, animals, soils, forest types).

Because the number of therapeutic plants recorded was too large to gather, prepare, and transport, only a subset of study plants was collected for further study. I concentrated on lesser known wild species that could be found. I was fortunate to be in Kayan-Mentarang during mast fruiting season, when several important plant families—Sapotaceae, Fagaceae, Burseraceae—fruit simultaneously. This synchronized burst of reproductive energy takes place at irregular intervals of two to ten years and usually lasts a few weeks or months. I was able to collect fertile specimens for a majority of the study plants, the presence of both flower and fruit allowing easier identification. All voucher specimens were made according to standard botanical collecting procedures as suggested by Alexiades and Sheldon (1996) and Martin (1995).

The majority of plant determinations were made by taxonomists at the Herbarium Bogoriense (BO) in Indonesia and the Leiden Rijksherbarium (L) in the Netherlands. A few taxa were identified by specialists at the Bishop Museum (BISH) in Honolulu, Hawai'i (LXG 105–98, *Pandanus gibbsianus* Martelli), the University of Aarhus in Denmark (all ten Zingiberaceae collections), and specialists working with the Lyon Arboretum (HAW), in Hawai'i. The Herbarium Bogoriense reviewed collections for adherence to the CITES (Convention on International Trade of Endangered Species) agreement. A complete set of each of the collections was distributed to: Lalut Birai field station (WWF-Indonesia Programme's Kayan-Mentarang project), Herbarium Bogoriense, the Leiden Rijksherbarium, and the Lyon Arboretum. I donated collection no. LXG 105–98 (*Pandanus gibbsianus*) to the Bishop Museum in Honolulu, Hawai'i and all ten Zingiberaceae collections to the University of Aarhus in Denmark.

I identified a number of common species (particularly pantropic fruits and vegetables found in yard gardens and fields) using illustrated botanical references (de Guzman and Siemonsma 1999; de Padua et al. 1999; Hutton 1996a, 1996b, 1997). In addition to botanical collections, I collected four insect samples: an immature and a mature moth larva, and a male and female beetle associated with the medicinal larva identified by an entomologist at the Bishop Museum.

Analysis of Study Plants and Cognitive Data.—Investigation of the ethnobotany, pharmacology and chemical constituents of plant parts and extracts of study plants was facilitated by using the NAPRALERT (Natural Products ALERT) Data Base as suggested by Etkin (1993) and Martin (1995). Analysis of cognitive data (free lists, pile sorts, ranking) was facilitated by using *Anthropac* version 4.71 (see Handwerker and Borgatti 1998).

KEY HEALING METAPHORS OF THE KENYAH LEPPO' KE

Three prominent concepts—matching, expelling, and shrinking—are central to understanding Leppo' Ke beliefs and practices and the therapeutic utility of certain sense properties. Hot-cold or humoral concepts are most frequently discussed within the framework of expelling and shrinking.

Teneng *(Matching).*—The belief that the patient must choose the most appropriate or ***teneng*** ('fitting', 'matching', 'compatible') medical practitioner and practice to effect a cure finds parallels in diverse cultural groups (e.g., Etkin 1992; Hardon

1994; Laderman 1991; Nichter 1989). The directive, "If one (therapy) doesn't work, just try another" was frequently invoked in resolving health complaints. Villagers thus commonly draw upon methods and medicines from more than one healing paradigm at a time, employing Kenyah medicines, biomedical pharmaceuticals, Javanese and Chinese manufactured liniments, or Malay charms in the search for the most fitting therapy. The approach to any therapy, local or introduced, is not "Does it work?" but "Does it work for me?"

Tai kawang *(Exiting).*—***Tai kawang*** involves coaxing disease out of the body and looking for visual signs of egress, it is a common therapeutic concept among native healing systems around the world (Etkin 1993b; Porter 1997). Many Leppo' Ke diseases result from a build-up of excess physical elements such as heat, cold, moisture, wind, or bodily fluids such as pus or blood, or poisons or foreign objects introduced into the body as a result of human or supernatural foul play. Sometimes these elements exit on their own, as wind may do in the form of flatulence or heat through sweating. More often than not, however, these conditions call for therapeutic intervention, such as using emetics, diuretics, or cathartics to draw out the agents of disease. Egress therapies underscore the chemical utility of plants. Plant irritants are a common feature of native healing systems for these purposes. For example, the urticaceous plant ***pei*** (*Dendrocnide stimulans* (L.f.) Chew), a kind of stinging nettle, is usually wholly avoided, but, villagers explained that it can be applied to open up a boil for draining.

Tai kupit *(Shrinking).*—Reduction of swelling of the skin or internal organs, joints, or bones is part of the process of healing. Tumescence occurs as a result of trespasses on somatic borders by wind, heat, and other causative agents. There are a number of techniques used for compressing, deflating, or shrinking afflicted areas of the body. For example, several bitter plants (e.g., *Tinospora crispa* (L.) Hook. f. & Thomson, *Eurycoma longifolia*) serve to drive fever out of the body *and* shrink the ***lu' ung kayung***, that is, the 'fever organ' or spleen. At the same time, spleen enlargement may be addressed externally by a number of means, but most typically by hot rock compresses using 'bitter' papaya leaves.

MAKING SCENTS OF *TABAN KENYAH* (KENYAH MEDICINE): THE LEPPO' KE MEDICINAL FLORA AND THEIR SENSE PROPERTIES

The Botanical Pharmacopoeia.—Study participants reported 216 locally distinguished medicinal folk species with 392 possible combinations or remedies made from local flora. Of the 192 taxonomically identified plants (116 voucher specimens collected plus 76 common garden species identified *in situ*), there are 182 angiosperms represented by 69 families and 10 pteridophytes represented by 7 families. Three medicinal fungi were identified in interviews, but none were available for collection. Over 92% of the Leppo' Ke botanical *materia medica* are identified as having one or more salient sensory properties, with only 16 out of the 192 taxonomically identified plants possessing no such quality. Often, plants that do not contain any of the sense properties summarized below have other distinctive physiological features in that they exude a colorful sap, are scabrous,

emollient, or soapy, or possess other features that mark them as plants of "perceptual salience" (Turner 1988).

Understandings of Sensory Properties: Leppo' Ke Taste Primaries.—Leppo' Ke olfactory, gustatory, and tactile sense terms are so numerous that I will not attempt to include and organize them all as others have done (see folk taxonomy schemes for the senses in, for example, Classen et al. 1994; Howes 1991; Johns 1990). For instance, there is the smell or taste of something charred (***tutung***), toasted (***lukui***), raw (***ata***), or rotten (***a'dam***); the sinewy, chewy texture of meat or fibrous plants (***sepit***); food not quite sweet enough to the taste (***nyelebiu***); food that is exquisitely sweet (***me'ding***); the fresh smell of newly fruiting paddy rice (***ba'o kamang***); or the fresh smell of young leaves or a newborn baby whose body has been bathed with *Blumea balsamifera* D.C. (***mengut***). Tactile terms are equally numerous. For instance, ***kesok*** refers to the irritating, painfully itchy quality from contact with urticaceous plants such as *Dendrocnide stimulans*, as opposed to ***katen***, which refers to itchiness without pain, usually the result of allergies or food sensitivities (e.g., salt fish, shrimp paste, mango sap). ***Ngelarek*** describes 'slimy' or 'mucilagenous' substances such as the contents of the fern *Blechum orientale* L.

Indo-Malay groups link their taste taxonomies to health and healing. Brunei Malay recognize seven basic flavors: bitter, astringent, sour, sweet, salty, spicy/hot, and *pahang* (the taste of chicken or certain cooked greens) (Kimball 1979). *Pahang* may be equivalent to the Japanese flavor enhancing or monosodium glutamate quality *umami* or the Leppo' Ke flavor ***jeleme***. Similarly, Leppo' Ke villagers recognize flavor principles of foods and medicines. Given the number of stimuli affecting taste terminology, it is difficult to separate basic from non-basic tastes. Nevertheless, a number of factors favor seven basic flavors: ***pa'it***, ***pa:t***, ***mesem***, ***me***, ***la'it***, ***sanit***, and ***jeleme***. These seven primaries begin the list of the nutrient and curative organoleptic properties of plants (Tables 1,2).

Pa'it literally and figuratively means bitter. Its foremost function is to chase illness out of the body (***apan tai kawang***, 'so it comes/goes out'). In that capacity, bitter substances are used primarily to alleviate fever (26 remedies). All of the "most effective" plants used for fevers are bitter (Tables 3, 4). In the words of one respondent, "If there is no bitter in the body, one *will* get sick with fever. That's why chloroquine is bitter." Only three of the fever treatments in the Leppo' Ke pharmacopoeia do not contain bitter elements. These non-bitter topical treatments are applied for their cooling (e.g., lemon basil, lemongrass) or sweat-inducing (e.g., shallot) effects. A common dietary prescription for someone who wants to avoid malaria is to increase the amount of bitter greens in their diet.

As an expellant ***pa'it*** may be used to hasten childbirth. The Tebulo birth attendant explained that ***pina*** 'quinine' antimalarial tablets are sometimes given to a woman after her water has broken because the bitterness makes the baby come out faster. Hence, strongly bitter substances are to be avoided during pregnancy unless abortion or miscarriage is intended.

Another function of ***pa'it*** is to shrink (***tai i'ut***) and compress (***tai kupit***). It is therefore employed to address the splenomegaly (spleen enlargement) that accompanies malaria, in addition to other fever regimens.

Bitter substances are also used to treat skin infections (13 remedies), stom-

TABLE 1.—Leppo` Ke common taste, smell and tactile terms, English descriptions, and associated species. Terms are approximately ordered from most to least common properties mentioned in ethnomedicine.

Leppo` Ke term	Description	Example
pa`it	bitter	*Eurycoma longifolia*
pa:t	astringent	*Areca catechu*
sanit	piquant, spicy, stinging or burning	*Capsicum* spp.
panah	hot, warming	mineral lime from *Cipangopaludina* sp.
sengim	cold, cooling	*Kalanchoe pinnata* (Lam.)
nglidah	(no English gloss) externally: cooling and numbing; internally: warming	*Litsea cubeba*
mesem	sour, tart	*Citrus* spp.
me	sweet	honey, sugar
la`it	salty or potent, strong	salt or alcohol
nglerak	slimy, mucilaginous	*Blechum orientale*
kesok	irritating, burning, itchy	*Dendrocnide stimulans*
lalih	zest	*Citrus* spp.
jeleme	*umami*, MSG, flavor-enhancing	tree fungi

achache and diarrhea (13 remedies) and dental caries (8 remedies). One man who had miraculously survived the potentially lethal bites of venomous snakes and centipedes on six occasions attributed his full recovery to having ***daa pa`it***, 'bitter blood'. Bitterness prevents or banishes poisons, worms or other unwanted intruders such as wind that introduce ailments through the skin, stomach, and mouth.

Pa:t literally means "tight," as in to tie a knot until ***pa:t***. Like ***pa`it***, ***pa:t*** is explicitly recognized as medicinal. Asked why a plant is good for medicine, peo-

TABLE 2.—Four Leppo` Ke primary taste and the first mentioned major disease category they are expected to cure, gleaned from a fill-in elicitation exercise conducted with 20 respondents (11 men and 9 women ranging in age from late teens to eighties and possessing varying degrees of botanical expertise).

	Primary taste terms							
	pa`it 'bitter'		***pa:t*** 'astringent'		***mesem*** 'sour'		***sanit*** 'spicy'	
Disease category	No.[1]	%[2]	No.	%	No.	%	No.	%
Dental caries	.	.	3	15	.	.	.	.
Eye	.	.	.	.	.	.	1	5
Fever	17	85	.	.	.	.	.	.
Gastrointestinal	3	15	15	75	1	5	1	5
Muscle/bone pain	.	.	.	.	.	.	.	.
Respiratory	.	.	.	.	10	50	.	.
Skin (wounds)	.	.	2	10	4	20	9	45
No association[3]	.	.	.	.	5	25	9	45
TOTAL	20	100	20	100	15	75	11	55

[1] Number of respondents that correlated given taste term with disease category.
[2] Percentage of respondents that correlated given taste term with disease category.
[3] Respondents who did not link a given taste term with a disease category.

TABLE 3.—Leppo' Ke disease categories and the four high consensus plants (and one moth larva) ranked as most effective for common health complaints. Plants are listed roughly in descending order from higher to lower consensus based on a combination of structured interviews.

Disease category (description)	Plants used for treatment (Leppo' Ke and Latin binomial)
mayung meko 'chills fever' (malaria)	***manjan*** (*Carica papaya*), ***paket limbang*** (*Eurycoma longifolia*), ***pria*** (*Momordica charantia*), ***aka pa'it*** (*Tinospora crispa*)
peli'en (a large category of numerous, differentiated rash or spot-producing fever diseases)	***ulet samban*** (moth larva), ***lirang tana'*** (*Clerodendron bethuniamum*), ***udu peli'en*** (*Gynura* cf. *aurantiaca*), ***bawing*** (*Ocimum tenuiflorum*)
puu 'sore/abrasion' (generally, pustular skin infections)	***aka padem*** (*Spatholobus gyrocarpus*), ***aka pale*** (cf. *Hemigraphis* sp.), ***pulut alim*** (*Mangifera pajang*), ***kayu bine*** (*Macaranga costulata*)
sakit batek mero (stomachache and severe, uncontrollable diarrhea); ***mero*** 'fruits dropping of a tree in fruiting season'	***li'bun*** (*Psidium guajava*), ***pa'an*** (*Areca catechu*) ***pa'ung lung*** (*Homalomena pendula*), ***puten*** (*Planchonia valida*)
sakit jipen 'toothache' (generally, dental caries)	***lelami*** (*Myrmeconauclea strigosa*), ***unga*** (*Piper betle*), ***bua' abung*** (*Nephelium rambutan-ake*), ***jelemutin*** (*Melastoma affine* cf. *malabathricum*)
suwat 'wound' (generally, fresh, bloody wounds)	***aka padem*** (*Spatholobus gyrocarpus*), ***udu Belenda*** (*Paspalum conjugatum*), ***mata atuk*** (*Callicarpa albida*), ***unga*** (*Piper betle*)

ple will state, for example, "Because ***li bun*** (*Psidium guajava* L.) is ***pa:t***, it is good for diarrhea." Because astringency "solidifies the contents of the stomach," it is useful for curing loose stools. Astringent properties are primarily used for gastrointestinal conditions involving diarrhea or dysentery (20 remedies). All of the consensus remedies imbibed for diarrhea with the exception of ***puten*** (*Planchonia valida* Blume) are defined as astringent (Tables 3, 4). All plants recognized as ***pa:t***, particularly those that are used as substitutes in a betel quid for areca nut (*Areca catechu* L.), are viewed as having healing potential, especially as stomachics and antidiarrheals, whether or not they are a part of the pharmacopoeia. Thus in every forest walk the strongly astringent ***aka kubung*** (no taxonomic identification) was identified first as a betel quid ingredient, but the supposition was always stated that it could be used to treat stomach problems "because it is ***pa:t***."

Pa:t plants pucker the skin and mouth and are thus useful for bloody wounds and abrasions (14 remedies), and for toothache and dental caries (8 remedies).

Mesem means "sour" or "tart." ***Mesem*** substances function as internal and external cleansers. It is a good therapeutic partner to ***pa:t*** in that both are drying and cleansing, hence good topical treatments for skin lesions. Generally, sour properties are also said to be cleansing, whether used to shine metals, scour away grease, or clean the body. Sour properties are used as fixatives for dye recipes for craft material as well as for the antifungal nail polish and wound healer made with ***selangga*** (*Impatiens balsamina* L.).

Mesem plants are also comprehended as rich sources of vitamins. Citrus fruits

are especially good for coughs and colds because they "hold many vitamins," an explanation more than likely introduced by government health workers.

Me means "sweet." ***Me*** 'sweet' substances are valued as poultice for contusions that are the result of trauma from a fall or bone break. Respondents associated ***me*** with the medicinal properties of honey and sugar, valued as poultice for contusions that are the result of trauma from a fall or bone break. The reasoning behind this use is that honey and sugar are said to dissolve clotted blood (***daa buku***), the hematomas that come with fractures and bruising. Honey is considered warming and so it is not only useful for breaking down "cold" blood obstructions, but is an essential ingredient in warming, strengthening tonics such as mixtures of sun bear gallbladder or ***paket limbang*** (*Eurycoma longifolia*). Here honey is added as a flavorant to tame the bitterness of the main ingredient. It is also considered fortifying.

La`it*** has two meanings. One is "salty." Several villagers linked the use of ***la`it as ***usen***, literally "salt," to caring for wounds or secondarily as a mouthwash for dental problems. People rub salt into their wounds, primarily as an admixture to hemostatic plants such as ***udu Belenda*** (*Paspalum conjugatum* Berg.).

The other meaning of ***la`it*** is "potent" or "strong," as in a particularly volatile alcoholic beverage or powerful medicine. ***Aka pejeling*** (*Aristolochia* sp.) is said to be such a ***la`it*** prophylactic for poisoning, that if you keep a piece of the vine in your pocket and someone has poisoned your drink, the glass will crack or even shatter before you can put it to your lips. ***La`it*** when associated with ***arak*** (whiskey made from distilled *Manihot esculenta* tubers) was noted, especially by older villagers, as an important warming tonic, good for relieving aching muscles and as a soporific.

Sanit means "spicy" or "piquant." It refers to properties found in chili peppers, garlic, ginger, betel leaf, black pepper, and so on, produced by a diversity of chemical compounds (e.g., capsaicin in chili peppers, zingerone in ginger, and piperine in black pepper) that are linked by a shared physiological effect—the hot, burning sensation called ***sanit***. Externally applied, ***sanit*** substances are used to prevent or treat pustular skin infections, as rubifacient for sore muscles and stomachache, and to expel foreign bodies from the eye. The majority of ***sanit*** remedies are used for skin infections (30 remedies).

Taken internally, ***sanit*** substances are utilized for their warming or heating properties; they draw out and extinguish the causative agents of infection and disease such as ***angin/bayu*** 'wind' and ***ulet*** 'worms'. Warming soups or strengthening tonics normally contain chili peppers and/or ginger. Internal curatives for wind and fever are often combined with external rubs from ***sanit*** ingredients such as a poultice of ***bawang bala*** (*Allium ascalonicum* L.), which is administered to help a patient sweat in order to break a fever.

Jeleme has two meanings. One is "bland." It also refers to ingredients that are bland, but at the same time serve as flavor enhancers. Commercial monosodium glutamate, commonly referred to as ***sasa***, epitomizes the quality of ***jeleme***, as do "***sasa Kenyah***" plants ***bekai lan*** and ***bekai lanya*** (*Pycnarrhena cauliflora* Diels and *Coscinium miosepalum* Diels) used for the same purpose. Most villagers reported no outright medicinal use for ***jeleme*** substances. Two respondents in elicitation exercises related ***jeleme*** to dietary proscriptions and prescriptions relevant

TABLE 4.—Leppo` Ke high consensus plants from Table 3 and some of their sensory attributes. Plants are listed in alphabetical order according to their Leppo` Ke names.

	pa`it	*pa:t*	*me*	*sanit*	*nglidah*	*panah*	*sengim*	*lalih*	Other sensory attributes
aka pa`it (*Tinospora crispa*)	X	.	.	.	.	.	.	.	
aka padem (*Spatholobus gyrocarpus*)	.	X	.	X	.	.	.	.	signature: produces red liquid when boiled
aka pale (cf. *Hemigraphis* sp.)	X	X	.	X	.	.	.	.	signature: produces red liquid when boiled
bawing (*Ocimum tenuiflorum*)	.	.	.	X	.	.	X	.	
bua` abung (*Nephelium rambutan-ake*)	X	X	.	.	X	.	.	.	
jelemutin (*Melastoma affine* cf. *malabathricum*)	.	X	.	.	.	.	.	.	
kayu bine (*Macaranga costuleta*)	.	X	.	.	.	.	X	.	signature: produces red liquid when boiled
lelami (*Myrmeconauclea strigosa*)	.	X	.	.	.	.	.	.	ants live in stem
li`bun (*Psidium guajava*)	X	X	.	.	.	.	.	.	only the over ripe fruit is ***jeleme***
lirang tana` (*Clerodendron bethunianum*)	X	.	.	.	.	.	.	.	
manjan (*Carica papaya*)	X	.	.	.	X	.	X	.	leaves and latex are bitter; only crushed seeds are ***nglidah*** to the taste
mata atuk (*Calliicarpa albida*)	.	X	.	.	.	.	.	.	edible fruit has slight menthol flavor
pa`an (*Areca catechu*)	.	X	.	.	.	.	.	.	betel quid component
pa`ung lung (*Homalomena pendula*)	X	.	.	.	.	.	.	.	fragrant tuber; red
paket limbang (*Eurycoma longifolia*)	X	.	.	.	.	.	.	.	

TABLE 4.—Continued.

	pa`it	*pa:t*	*me*	*sanit*	*nglidah*	*panah*	*sengim*	*lalih*	Other sensory attributes
puten (*Planchonia valida*)	.	X	X	.	.	.	.	.	inner bark has sweet and astringent flavor
pria (*Momordica charantia*)	X	.	.	.	.	.	.	.	
pulut alim (*Mangifera pajang*)	.	.	.	.	.	.	.	X	latex is irritant but medicinal when heated
udu Belenda (*Paspalum conjugatum*)	.	.	.	X	.	.	X	.	stings broken skin
udu peli`en (*Gynura* cf. *aurantiaca*)	.	.	.	.	.	.	X	.	semisucculent
ulet samban (moth larva)	.	.	.	.	X	X	X	.	***parih ba`o*** 'strong smell'
unga (Piper betle)	X	.	.	X	X	.	X	.	betel quid component

to health. People wanting to avoid edema, such as beriberi patients and pregnant and postpartum women, are advised to avoid salt and stick to ***jeleme*** (i.e., bland, non-salty) diets. ***Jeleme*** diet should also be adhered to by those suffering from hot and ***katen*** 'itchy' ailments such as fever blisters, oral thrush, and similar skin ailments that may be the result of allergies or food sensitivities.

There are many Leppo' Ke non-basic taste terms and synonyms. These subsidiary flavors (and associated olfactory and tactile qualities) sometimes can be of consequence to health. For example, ***dangang*** is closely related to bitterness. It is a scratchy, stinging, gagging sensation at the back of the throat when one tastes or smells especially bitter varieties of manioc or bamboo shoots. The term ***dangang*** identifies the bitter-toxic bite of hydrogen cyanide (HCN) that is released into the atmosphere when the tissues of manioc or bamboo shoots are disrupted during collection and processing (Johns 1990). Whereas bitter plants are considered powerful fever medicines, ***dangang*** holds no such value. Rather, too much ***dangang*** in the diet causes or exacerbates skin conditions such as acne or the fungal infection 'ringworm'. ***Dangang*** is related to ***katen*** substances, mentioned above, that are proscribed for ***panah*** 'hot' conditions.

Another example is ***meden***, closest to the English word "gamy" used to describe the taste of wild meats. Scientists have isolated a few fatty acids (principally, 4-methyloctanoic, 4-ethyloctanoic and 4-methylnonanoic) that account for the musky flavor of feral foods such as venison, mutton and turkey (Brennand et al. 1989). However, the Leppo' Ke term ***meden*** is even more precise. It refers specifically to the taste and smell of the fat that lies in and around the intestines of the bearded pig (*Sus barbatus* Müller). It is universally considered foul. When people render pig fat for cooking oil they generally discard ***meden*** adipose tissue except in times of extreme scarcity. Rancid pig fat is also ***meden***. The extremely oily fruit of *Pangium edule* Reinw., used to make a rich fermented condiment (***payang kayu***), may also turn ***meden***. Even some dry shrubs and trees—***lelami*** (*Myrmeconauclea strigosa* Merrill), ***lelami saleng*** (*Ficus* sp.) and ***laran lî bun*** (*Syzygium* sp.)—are said to have a ***meden*** quality. All three of these species have therapeutic applications. However, the sensory attribute ***meden*** in and of itself is not regarded as useful for promoting health or treating disease.

Consensory Plants and Perceptions of Efficacy.—Table 1 presents Leppo' Ke common taste, smell, and tactile terms, English descriptions of each, and associated species. Table 2 presents Leppo' Ke primary taste terms and the major disease categories they are expected to cure as gleaned from one of the sentence completion exercises. Table 3 presents the plants recognized as most effective for a given health complaint in rough descending order from higher to lower consensus based on a combination of structured interviews. Order of preference is based on the combined results of the ranking exercise in addition to information provided in interviews, and through observation of use (a triangulation of methods recommended by McNabb 1990). Like assessments of efficacy, chemosensory assignments were ascertained through triangulation of quantitative and qualitative methods. Any given plant may possess multiple healing characteristics and serve a variety of therapeutic needs. I have presented the most prominent features and functions of plants as told to me by Leppo' Ke consultants. Sensory distinctions

dominated discussions of a plant's power and value. One cultural caveat should be noted; the fundamental concept of ***teneng*** 'appropriateness' prevails in most medical matters. With few exceptions, participants in efficacy protocols commented on the impossibility of ranking therapies and would preface an answer by stating that "it depends on what medicine/s is appropriate" for a given case and patient. My more precise phrasing, "what works best and is most appropriate (***teneng***) for *you* in *your* experience or in your administrations to others" elicited more responses, but always with the warning that the proper fit is situational.

NGLIDAH: A COMPLEX OF HEALING SENSATIONS

The Mystery of Moths, Ping Bawing, and Medicine.—The Leppo' Ke property ***nglidah*** describes a complexity of taste, smell, and tactile qualities for which there is no simple English gloss. ***Nglidah*** plants straddle culinary, therapeutic, and ritual use categories, but are not explicitly tied to any one. Several plants possess this quality, as does ***ulet samban***, a fatty Cossidae moth larva that has the pungent flavor and odor of acrid cilantro and epitomizes ***nglidah*** according to many respondents. Confounding to characterize, ***nglidah*** can be found in the flavor, and/or smell, and/or feel of *Piper betle* L. and related species of *Piper*, in the sweet and strongly citronella-smelling peppercorns of ***beleng la*** (*Lindera pipericarpa* Boerl. or *Litsea cubeba* Pers.), in ***ping bawing*** (*Cymbopogon citrates* Stapf), in a handful of gingers such as ***seriteng*** (*Etlingera* aff. *metriocheilos* (Griff.) R.M.Smith) and ***lia lamut*** (*Alpinia galanga* Willd.), and in aroids such as ***pa' ung lung*** (*Homalomena pendula* (Blume) Bakh.f.) and ***lung adek*** (*Homalomena cordata* Schott), to name the most typical examples. In papaya, only the peppery crushed seeds are considered ***nglidah***. The olfactory emissions of gingers such as *Etlingera* aff. *metricheilos*, *Etlingera punicea* (Roxb.) R.M. Smith, and the peppery-smelling rhizome of the unidentified *Zingiber* ***lia skala*** are loud and complex. Plants possessing piperine and citronella compounds (e.g., ***unga***, ***beleng la***, ***ping bawing***, and a folk variety of lemongrass that has a strong citronella odor called ***ping bawing beleng la***), as well as commercial citronella mosquito spray, all typify ***nglidah***. Some ***nglidah*** items are only dubbed so in a single sensory mode. For instance, commercial mentholatums, such as the favorite household analgesic and disinfectant cajuput oil, have a cooling and warming effect on the skin that feels ***nglidah***, but does not taste or smell ***nglidah***. Similarly, the anise-like, slightly petroleum-like, menthol smelling and tasting pith of *Etlingera* aff. *metriocheilos* that is used to treat severe leg cramps and atrophy is primarily ***nglidah*** on the skin, possessing a cooling sensation.

Initially I assumed that ***nglidah*** could best be described as cilantro-like, having experienced the refreshing and at the same time buttery rich taste of ***ulet samban***. I was further convinced by tasting a garden weed (unidentified Apiaceae) brought to me by a neighbor who wanted to give me a better sense of the sense ***nglidah***. It too had the distinct flavor of coriander and is a member of the Apiaceae family. I then thought that perhaps it is more the quality of piper and citronella found in the plants described above. Or perhaps it is the menthol or anise element emitted from *Etlingera* aff. *metriocheilos*. The triumvirate of ***panah*** 'warming', ***sengim*** 'cooling', and ***nglidah*** properties typical of ***nglidah*** topical remedies all have the cooling and numbing characteristic of mentholated balms.

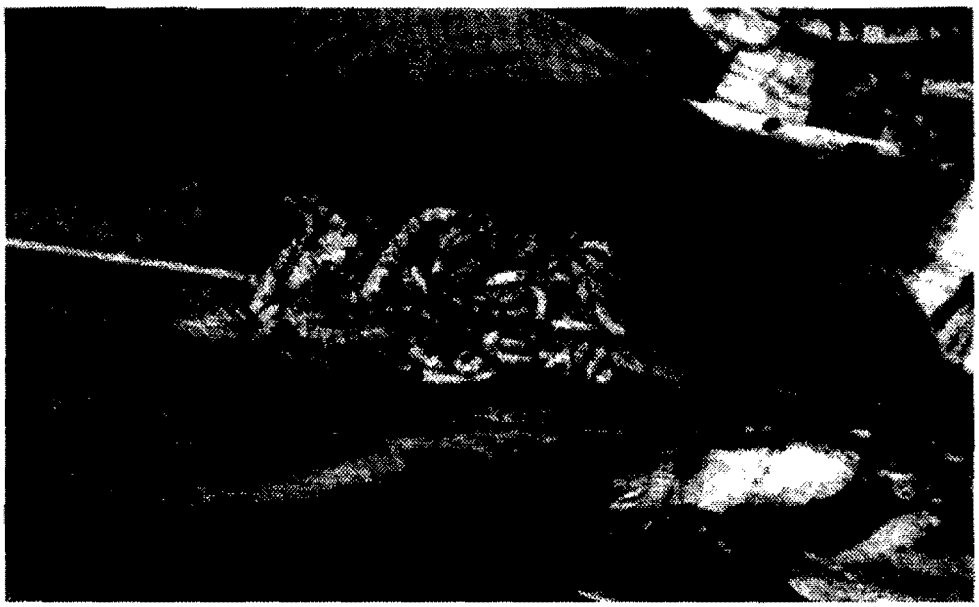

FIGURE 3.—***Ulet samban***, moth larvae used as food and medicine, epitomize the flavor, smell, and feel of the sense property ***nglidah*** according to Leppo' Ke consultants.

Perhaps it is the quality of mint? A few respondents tasted a mint candy and a licorice lozenge, describing the licorice as ***nglidah*** but not the mint candy. At first glance, it was impossible to group ***nglidah*** items based on organoleptic similarities. Nevertheless after encountering a number of ***nglidah*** substances, I gained a holistic appreciation of this sense property.

What characteristics do these seemingly disparate species and suite of qualities share? Clearly, all are strongly aromatic and high in essential oils. Many are rubifacients. The majority of ***nglidah*** species, with the exception of the aroids, are important comestibles and masticatories. ***Nglidah*** therapies satisfy a range of needs from pediatric fevers, to stomach complaints, to muscle aches and cramping, and more. According to several respondents, remedies ingested via the skin are especially good for resolving ***pelî en***, a wide range of spot or rash-producing febrile conditions. All forms of ***pelî en*** are caused by wind entering the body and ***nglidah*** therapies are especially helpful because they draw out the heat that accumulates deep within the body as a result of ***bayu*** 'wind' ingress. Orally ingested ***ulet samban*** (Cossid larvae, Figure 3) warm the cold interiors of an elder suffering from ***sakit sengim*** 'cold sickness', and cool and absorb heat from the fevered interior of a child sick with ***pelî en*** when applied topically. *Homalomena pendula* expels intestinal worms from a sick stomach. And *Etlingera* aff. *metriocheilos* is wrapped around joints to revive cramped or paralyzed limbs.

Essentializing Essence Oils.—The enigmatic Leppo' Ke property ***nglidah*** is in fact distinguished by a number of ethnobotanical, evolutionary, chemotaxonomic, and pharmacological commonalities. With one exception (*Carica papaya*), ***nglidah*** plants are Old World tropical species: many are components of the Malesian flora (e.g.,

Etlingera elatior (Jack) R.M.Sm.) and at least one may be native to Borneo (*Amomum ligulatum* R.M.Sm.). The intersection of food, masticatories, and medicines is particularly evident with ***nglidah*** plants. Many of these species are eaten, primarily as herbs and spices; a few have a history of use in the spice trade (e.g., *Lindera pipericarpa, Litsea cubeba, Cymbopogon citratus, Alpinia galanga, Ocimum tenuiflorum*). *Piper betle* leaf and substitutes (e.g., ***unga tana`***, *Piper* sp.) are a ***nglidah*** component of the betel quid. A number have important magico-religious meaning, used in ritual healing and to counter spirit or human curses, for example, as incense and talismans. As medicines, most are administered via the skin (usually in combination with internally consumed therapies) and produce a rubifacient and analgesic effect.

There is chemotaxonomic affinity shared by ***nglidah*** taxa. All ***nglidah*** plants contain terpene and terpene-derivative compounds, especially highly volatile monoterpenes such as α-pinene, 1,8 cineole, limonene, and piperitone. These and a number of other constituents found in ***nglidah*** species account for the citrus, citronella, black pepper and pungent, slightly mentholated and topically numbing, and sometimes coriander and licorice-like qualities. The volatile oils that occur in ***nglidah*** plants can affect a complex range of actions on human physiology with pharmacologic implications for health. Broadly, they are antimicrobial (antibacterial, antifungal, vermifugal) and thus possibly useful for fighting fever and other infections. They possess decongestant and expectorant properties, possibly making them useful for treating respiratory complaints. They are internally and externally counterirritant, possibly making them useful analgesics for muscle and bone distress, as well as for relieving intestinal distress, since they possess carminative, antispasmodic, and appetite-stimulating potential (e.g., Deans and Waterman 1993; de Guzman and Siemonsma 1999; Harborne and Tomas-Barberan 1991; Oyen and Dung 1999). (For an in-depth exploration of the phytochemical and pharmacological implications of ***nglidah*** taxa see also Gollin 2001.)

Interestingly, the high consensus medicine and coveted delicacy, cossid moth larvae, shares most of the above characteristics that for Leppo` Ke consultants epitomizes ***nglidah***. The theme of endemism and the antiquity of ***nglidah*** taxa suggest an ancient origin for this folk category. ***Ulet samban*** is a member of the Cossidae, an ancient family that is widely distributed throughout Asia and Australia (Nielsen and Common 1991). In Tebulo, the moth larve pupate in the pith of ***seleman*** (*Glochidion* cf. *phillipicum* (Cav.) C.B. Rob.) and other trees in different locales. *Glochidion* is an important dye plant, the juicy, blood red fiber of which is squeezed to make a black dye for sunhats and other woven crafts. Grubs live gregariously in galleries excavated beneath the bark and in association with large black horned beetles (*Eurytrachelus titanus*) (also collected and identified for this study). In the case of the Cossidae species collected for this study, the smaller, younger, larvae are a buttery yellow color. As they mature they become yellow-red. The fat, mature larvae take on a blood red color identical to that of the moist red sapwood in which they live. All possess the characteristic aroma of ***nglidah***, but mature larvae are most strongly redolent of acrid cilantro and are regarded as the most potent medicine.

It is also worth noting that the oily, odorous Cossidae larvae are chemically—and by extension pharmacologically—provocative. The striking ***nglidah*** odor of

the Cossidae larvae is not found in the host tree. While the Cossidae specimens are clearly absorbing the red sap of *Glochidion*, they possess an odor that is all their own. Whether sequestering or biosynthesizing compounds *de novo*, or a combination of both, like pills, larvae are chemicals concentrated.

DISCUSSION AND CONCLUSION

Many native systems utilize organoleptic indicators for assembling their pharmacopoeia, favoring certain sensory cues over others. For instance, taste was the primary means of evaluating medicinal plants by the Algonquians of North America (Speck 1917). The Yabashta of the Peruvian Amazon emphasize visual, tactile, and aromatic properties of medicinal plants, but have little interest in their taste (Shepard 1999). For the Kenyah Leppo' Ke a number of organoleptic characteristics of plants are of paramount importance for identifying and utilizing medicines.

In this paper I have accentuated taste and odor cues, and to a smaller extent tactile features, over other signs of a plant's therapeutic value. Physiological distinctiveness may also contribute to a plant's perceptual salience and therapeutic value. Some Leppo' Ke species possess an obvious ***ta' ding***, or 'sign', of their use. For instance, ***utan bang*** (*Amorphophalus* sp.) is applied to skin dispigmentation because the mottled marks on the main stem resemble the blotchy patches of ***litak*** (vitiligo). The connection between red features of plants and blood disorders is an especially common signature in diverse medical systems. Several treatments for bloody wounds, internal hemorrhagic conditions, as well as ***keri' ut daa*** 'low / little blood' (anemia), call for plants with a red exudate, or that yield a red decoction, or infusion or have prominent red parts. For example, ***aka padem*** (*Spatholobus gyrocarpus* Benth.), ***aka pale*** (cf. *Hemigraphis* sp.), ***kayu bine*** (*Macaranga costulata* Pax & K. Hoffm.), ***kayu lenganing*** (*Antidesma venenosum* J.J. Smith), and ***selangga*** (*Impatiens balsamina*) are fresh wound healers; ***paku bala*** (*Stenochlaena palustris* Bedd.) is a blood strengthener used to treat anemia.

An interesting Leppo' Ke example of a non-visual sensory signature is ***udu sin bu' in*** 'domestic pig meat herb' (*Ampelocissus imperialis* Planch.), so named because it smells like pig meat. Applications of the leaves to ***bengo*** pits (infection characterized by deep craters on the skin) are said to encourage the ***sin*** 'flesh' or 'meat' to regrow.

Symbolically meaningful chemical sense properties (e.g., bitterness, astringency, pungency, urtication) and visual cues (e.g., milky latex associated with galactagogues, red plants with the ability to resolve blood conditions, or yellow plants with jaundice remedies), are cultural constructions that often have a biological basis. This does not discount the wealth of plants with obvious chemical signatures (and therapeutic potential) that go wholly ignored by human consumers. Not all plants with a blood red exudate are employed as wound-healers. Not all bitter plants are considered therapy for febrile or gastrointestinal conditions. Rather, such attributes function as a mnemonic for earmarking a subset of taxa in a biologically diverse and chemically complex environment (Etkin 1988). In other words, in plant-dependent societies, a plant that is astringent may be more worth testing for its antidiarrheal potential than one that is not.

Until recently, the most extensive phytopharmaceutical investigations have

been concerned with the search for bitter alkaloids (Deans and Waterman 1993). A number of ethnopharmacological investigations have centering on the salience of bitter, and secondarily astringent, principles in native plant pharmacopoeia (indicating the potential presence of alkaloids compounds in the former and polyphenolics in the latter). Bitter compounds are omnipresent in our floral environment and in pharmacopoeia. Given the therapeutic utility of bitter repellent and toxic botanical compounds for humans, the bitter bias in the ethnopharmacological and ethnobotanical literature is understandable. But certain questions are left unanswered. For instance, few inquires have compared medicinal to non-medicinal flora and also checked for the frequency of bitter contents (Ankli et al. 1999 and Leaman 1996 are two admirable exceptions, a point also made by Casagrande 2001).

Local categories such as ***nglidah*** call attention to the importance of plant medicines high in volatile and essential oils.[1] While traditional use of volatile and essential oils for commercial and folk food flavoring, preservation, and fragrances is well-documented, few ethnobotanical investigations have focused on the role of these aromatics in native botanical therapeutics. This is surprising considering that volatile oils are widely distributed in tropical and temperate angiosperms, especially in mints (Lamiaceae), eucalypts (Myrtaceae), peppers (Piperaceae), citrus (Rutaceae), and bays (Lauraceae) (Cotton 1996).

A rare example is research conducted among the people of Siberut Island off the coast of Sumatra. The curative sensory quality ***makasak*** bears a resemblance to ***nglidah***, characterized by aromatic species such as *Piper betle, Litsea elliptica* Blume, *Acorus calamus* L., and *Cananga odorata* Hook.f. & Thomson (Ave and Sunito 1990). ***Makasak*** plants are used to treat contusions, sprains, and bone fractures.

Another example is research on the Nekematigi people of the New Guinea Highlands. Chemotaxonomically related species that are rich in volatile oils account for the greatest portion of medicinals of the Nekematigi. Volatile oil plant therapies constitute the fundamental "all purpose" medicines, that is, plants with inherently health-restorative properties are prescribed in all cases for their positive effects on a sick person and supplemented with targeted therapies that have negative effects on specific illness agents. The fragrance of Nekematigi medicines is believed to "carry" the power of the plant and the healer's incantations through the body, and is an essential mediator between the patient and the plants she or he consumes. Nekematigi comprehend certain aromatics as being capable of "opening" up the body (Johannes 1986). Like Leppo` Ke ***nglidah*** and ***makasak*** plants used in Siberut, Nekematigi "all purpose" medicinals represent aromatic families such as Zingiberaceae and genera such as *Cinnamomum* (from the aromatic family Lauraceae).

Leppo` Ke ***nglidah*** rubefacients, in addition to being pain-killing, are understood to open up the pores to let internal wind and heat escape. Components such as camphor, menthol, and eugenol found in ***nglidah*** topical treatments stimulate trigeminal responses and produce a variety of actions (Lawless and Heymann 1999). Menthol and camphor (both present in commercial liniments) can either enhance or inhibit warm or cold stimuli depending on the nature of the stimulation (Lawless and Heymann 1999). The monoterpene compound linalool found in ***nglidah*** plants is a major component of several aromatic species, many

of which are used around the globe as sedatives, including for the purpose of interruption and prevention of seizures (Elisabetsky et al. 1995), an application also reported among the Kenyah. Linalool has demonstrated anticonvulsant properties in laboratory analysis (Elisabetsky et al. 1999). Additionally, in Borneo, and certainly among the Kenyah, scent carries symbolic weight that serves as preventive or cure against sickness or misfortune due to foul play by spirits or the malevolent actions of humans (e.g., Conley 1975; Winzeler 1993). The use of aromatics is omnipresent in ritual healing and in daily life in the forms of incense, botanical smoke and steam baths, and the many odoriferous charms found in homes, on baby carriers, in bathing new mothers and infants, and so on (Gollin 2001).

Kenyah Leppo' Ke sensory evaluation of plants—as well as animals, minerals and Western-style pharmaceuticals (Gollin 2001)—is an important means by which people come to know and employ efficacious medicines as evidenced by the chemical provenance of the Leppo' Ke sense property ***nglidah***. Seemingly disparate floral and faunal species defined as ***nglidah*** by the Kenyah Leppo' Ke are in fact related by key chemical notes (e.g., citral, limonene, piperitone). They exert a range of physiological effects that may relieve discomfort (e.g., *Etlingera* aff. *metricheilos* used for joint cramping) and resolve disease (*Litsea cubeba* used for febrile conditions). ***Nglidah***, as well as purely culinary descriptors such as ***jeleme***, ***dangang***, and ***meden***, accentuate an important factor in Kenyah Leppo' Ke sensory acumen. Cuisine is a significant determinant of perception. The taste properties of glutamate and aspartate salts form the building blocks of flavor principles in some ethnic (notably Asian) culinary traditions (Lawless and Heymann 1999: 43). It is not surprising that Japanese have a taste term (*umami*) to describe the distinct flavor-enhancing sensation of miso or sea tangle, or that Leppo' Ke use the term ***jeleme*** to describe certain fungi and leaf additives (e.g., *Pycnarrhena cauliflora*), a quality that goes unnamed in other cultures. Similarly, the properties ***jeleme***, ***dangang***, and ***meden***, while not explicitly medicinal, identify very specific chemistries—the first that of monosodium glutamate, the second the volatile cyanogenic glycosides encountered in manioc and bamboo shoots, and the third possibly the fatty acids of feral food—of consequence to health.

Scholars in a small branch of anthropology known as the "anthropology of the senses," like ethnobiology an intellectual offspring of linguistic and cognitive anthropology, have identified cultural "sensotypes" (Wober 1966). That is, different cultures demonstrate different levels of "sense-ability" based on the prevailing patterns of childhood intake and proliferation of information from the various sense modalities (Wober 1991). Cultural differences in the precision of language to express a particular sense may influence and be influenced by sensory perception. For instance, scholars have explored the relationship between odor taxonomies and sensory perception. Elaborate osmologies (the classification and interpretation of smells) across cultures underscore Leenhardt's paradigm—the thesis that the more comprehensive a society's olfactory vocabulary, the more odors are regarded as revealing, whereas less comprehensive registers suggest a suppression of smells altogether (Leenhardt 1979 in Howes 1988).

My objective in this investigation was to observe and elicit the various senses (primarily smell, taste, and touch) that come into play in health and healing. In

so doing I found that the chemical dénouement of less obvious sensory attributes is an alternative way to explore the link between human cognition and communication (i.e., ethnobiology) and expectations of therapeutic outcome (i.e., ethnopharmacology and ethnobotany), and suggests fertile ground for further study of these related scientific endeavors.

NOTES

[1] The terms "volatile" and "essential" are often used interchangeably. They are somewhat different. A volatile substance is one that evaporates at room temperature and is an essential property of odorous materials. Essential oil is a volatile product obtained from a natural source, possessing the odor and other characteristic properties of the plant. In a narrow sense only volatile products obtained by steam or water distillation are called essential oils (Oyen and Dung 1999).

ACKNOWLEDGMENTS

First and foremost I thank the good people of Long Tebulo and surrounding villages for their enthusiasm and support, their constant good humor, and for protection from *kelamun* 'headhunters'. I express my deepest appreciation to Ba' un Uluk, my astute research associate and kid sister, and the Uluks, my host family. I owe a debt of gratitude to the many individuals and institutions that have made this work possible. My field research was supported by a Fulbright-Hays Doctoral Dissertation Fellowship (award no. PO22260043) and a National Science Foundation Dissertation Improvement Grant (award no. SBR96–14148). The writing phase was supported by the American Association of University Women. In Indonesia I received institutional support from The Indonesian Institute of Sciences (LIPI), the Indonesian Directorate of Forest Protection and Nature Conservation (PHPA) and the World Wide Fund for Nature, Indonesia Programme (WWF). I am especially grateful to Nelly Polhaupessy (AMINEF) and Dr. Dedy Darnaedi (Puslitbang Biologi). Special thanks also goes to all the scientists who identified floral and faunal study specimens: Dr. Ismael at Herbarium Bogoriense; Dr. van Balgooy, Dr. Adema, Dr. Hovenkamp, Dr. Veldkamp, Dr. Kessler, Dr. Slik, Dr. Middleton, Dr. Ridsdale, Dr. Haegens, Dr. Hou and Dr. de Wilde at Leiden Rijksherbarium; Dr. Puttock at the Bishop Museum; Dr. Charles Lamoureux and John Mood at the Lyon Arboretum; and the entomologist Dr. Samuelson at the Bishop Museum in Hawai'i. Dr. Norman Farnsworth, Dr. Doel Soejarto and Mary Lou Quinn-Beattie at the Program for Collaborative Research in the Pharmaceutical Sciences (University of Illinois, Chicago) kindly granted me free access to the NAPRALERT database. Dr. Paul Cox, Director of the National Tropical Botanical Garden (NTBG) in Kauai, provided the peaceful and stunningly beautiful writing refuge and resources that made this paper possible. Finally, I express my unbridled aloha to all those who provided comments, translation, and editorial assistance on the final draft of this paper: Dr. Nina Etkin, Dr. Will McClatchey, Dr. Tamara Ticktin, Gustavo De la Peña, and Jaida Samudra.

REFERENCES CITED

Alexiades, M.N. and J.W. Sheldon, eds. 1996. *Selected Guidlines for Ethnobotanical Research: A Field Manual*. The New York Botanical Garden, Bronx.

Anau, N. 1998. *Sejarah Leppo' Ke dan Ngibun Apau Ping kecamatan Long Pujungan*. World Wide Fund for Nature, Indonesia Programme, Samarinda.

Ankli, A., O. Sticher, and M. Heinrich. 1999. Yucatec Mayan medicinal plants vs.

non-medicinal plants: selection and indigenous characterization. *Human Ecology* 27:557–580.

Ave, W. and S. Sunito. 1990. *Medicinal Plants of Siberut. A World Wide Fund for Nature Report.* WWF International, Switzerland.

Bartoshuk, L. 1978. A history of research on taste. In *Tasting and Smelling: Handbook of Perception,* eds. E. C. Carterette and M.P. Friedman, pp. 503–567. Academic Press, New York.

Berlin, E.A. and B. Berlin. 1996. *Medical Ethnobotany of the Highland Maya of Chiapas, Mexico: The Gastrointestinal Diseases.* Princeton University Press, Princeton.

Berlin, B. and P. Kay. 1969. *Basic Color Terms.* University of California Press, Berkeley.

Bernard, H.R. 1994. *Research Methods in Anthropology: Qualitative and Quantitative Approaches.* Sage, Newbury Park, California.

Brennand, C.P., K.J. Ha, and R.C. Lindsay. 1989. Aroma properties and thresholds of some branched-chain and other minor volatile fatty acids occurring in milk fat and meat lipids. *Journal of Sensory Studies* 4:105–120.

Brett, J.A. 1994. Medicinal plant selection criteria among the Tzeltal Maya of Highland Chiapas, Mexico. Ph.D. Dissertation (Medical Anthropology), University of California, San Francisco.

Brett, J. A. and M. Heinrich. 1998. Culture, perception and the environment: the role of chemosensory perception. *Angewandte Botanik* 72:67–69.

Brun, V. and T. Schumacher. 1987. *Traditional Herbal Medicine in Northern Thailand.* University of California Press, Berkeley.

Casagrande, D.G. 2001. Ecology, Cognition, and Cultural Transmission of Tzeltal Maya Medicinal Plant Knowledge. Ph.D. Dissertation (Anthropology), University of Georgia, Athens.

Classen, C., D. Howes, and A.J. Synnott. 1994. *Aroma: The Cultural History of Smell.* Routledge, London.

Conley, W.W. 1975. *The Kalimantan Kenyah: A Study of Tribal Conversion in Terms of Dynamic Cultural Themes.* Presbyterian and Reformed Publishing Co., Nutley, New Jersey.

Cotton, C.M. 1996. *Ethnobotany: Principles and Applications.* John Wiley and Sons, Ltd., England.

Deans, S.G. and P.G. Waterman. 1993. Biological activity of volatile oils. In *Volatile Oil Crops: Their Biology, Biochemistry and Production,* eds. R.K.M. Hay and P.G. Waterman, pp. 97–112. Longman Scientific and Technical, Essex.

de Guzman, C.C. and J.S. Siemonsma, eds. 1999. *Spices.* Plant Resources of South-East Asia, vol. 13. Backhuys Publishers, Leiden.

de Padua, L.S., N. Bunyapraphatsara, and R.H.M.J. Lemmens, eds. 1999. *Medicinal and Poisonous Plants (1).* Plant Resources of South-East Asia, vol. 12. Backhuys Publishers, Leiden.

Elisabetsky, E., G.P.C. Souza, M.A.C. Santos, I.R. Siqueira, and T.A. Amador. 1995. Sedative properties of linalool. *Fitoterapia* 15:407–414.

Elisabetsky, E., L.F. Silva Brum, and D.O. Souza. 1999. Anticonvulsant properties of linalool on glutamate related seizure models. *Phytomedicine* 6:113–119.

Elvin-Lewis, M., J.B. Hall, M. Adu-Tutu, Y. Afful, K. Asante-Appiah, and D. Leiberman. 1980. The dental health of chewing-stick users of southern Ghana: preliminary findings. *Journal of Preventive Dentistry* 6:151–159.

Etkin, Nina L., 1988. Ethnopharmacology: biobehavioral approaches in the anthropological study of indigenous medicines. *Annual Review of Anthropology,* 23: 23–42.

———. 1992. "Side effects": cultural constructions and reinterpretations of Western pharmaceuticals. *Medical Anthropology Quarterly* 6:99–113.

———. 1993a. Anthropological methods in ethnopharmacology. *Journal of Ethnopharmacology* 38:93–104.

———. 1993b. The negotiation of 'side' effects in Hausa therapeutics. In *Medicines: Meanings and Contexts,* eds. N.L. Etkin and M.L. Tan, pp. 17–32. Health Action Information Network, Quezon City, Philippines.

Etkin, N.L., L.X Gollin, D. Binnendyk, and H. Soselisa. 1996. Ethnomedicine in Maluku, Eastern Indonesia. *Cakalele* 7: 33–50.

Etkin, N.L. and P.J. Ross. 1982. Food as medicine and medicine as food: an adaptive framework for the interpreta-

tion of plant utilization among the Hausa of Northern Nigeria. *Social Science and Medicine* 16:1559–1573.

Etkin, N.L., P.J. Ross, and I. Muazzamu. 1990. The indigenization of pharmaceuticals: therapeutic transitions in rural Hausaland. *Social Science and Medicine* 30:919–928.

Gollin, L.X. 1991. Searching for Medicinal Plants with a Dukun in Seberida, Sumatra. *Jakarta Post*, Jakarta.

———. 1993. *Apotik hidup*: Indonesia's living apothecary. *HerbalGram* 29:10–15.

———. 1997a. Having your medicine and eating it too: a preliminary look at medicine and meals in Kayan-Mentarang, Kalimantan, Indonesia. *Borneo Research Bulletin* 28:28–41.

———. 1997b. Taban Kenyah: a preliminary look at the healing plants and paradigms of the Kenyah Dayak people of Kayan-Mentarang. In *People and Plants of Kayan-Mentarang*, eds. K.W. Sorenson and B. Morris, pp. 135–148. World Wide Fund for Nature, London.

———. 2001. The Taste and Smell of Taban Kenyah (Kenyah Medicine): An Exploration of Chemosensory Selection Criteria for Medicinal Plants among The Kenyah Leppo' Ke of East Kalimantan, Borneo, Indonesia. Ph.D. Dissertation (Anthropology), University of Hawai'i, Honolulu.

Handwerker, W.P. and S.P. Borgatti. 1998. Reasoning with numbers. In *Handbook of Methods in Cultural Anthropology*, ed. H.R. Bernard, pp. 549–594. AltaMira Press, Walnut Creek, California.

Harborne, J.B. 1988. *Introduction to Ecological Biochemistry*. Academic Press, London.

Harborne, J.B. and F.A. Tomas-Barberan. 1991. Ecological chemistry and biochemistry of plant terpenoids. In *Proceedings of the Phytochemical Society of Europe*, vol. 31, eds. J. B. Harborne and F. A. Tomas-Barberan, pp. 399–426. Oxford University Press, Oxford.

Hardon, A.P. 1994. People's understandings of efficacy for cough and cold medicines in Manila, the Philippines. In *Medicines: Meanings and Contexts*, eds. N.L. Etkin and M.L. Tan, pp. 47–68. Health Action Information Network, Quezon City, Philippines.

Hartman, T. 1991. Alkaloids. In *Herbivores: Their Interactions with Secondary Metabolites*, vol. 1, eds. G.A. Rosenthal and M. R. Berenbaum, pp. 79–123. Academic Press, San Diego.

Heinrich, M. 1994. Herbal and symbolic medicines of the Lowland Mixe (Oaxaca, Mexico): disease concepts, healers' roles and plant use. *Anthropos* 89:73–83.

———. 1998. Indigenous concepts of medicinal plants in Oaxaca, Mexico: lowland Mixe plant classification based on organoleptic characteristics. *Journal of Applied Botany* 72: 75–81.

Heinrich, M. and N.A. Barrera. 1992. Indigenous phytotherapy of gastrointestinal disorders in a lowland Mixe community (Oaxaca, Mexico): ethnopharmacological evaluation. *Journal of Ethnopharmacology* 36:63–80.

Howes, D. 1988. On the odour of the soul: spatial representation and olfactory classification in Eastern Indonesia and Western Melanesia. *Bijdragen tot de Taal, Land en Volkenkunde* 144:84–113.

———. 1991. *The Varieties of Sensory Experience: A Sourcebook in the Anthropology of the Senses*. University of Toronto Press, Toronto.

Hutton, W. 1996a. *Tropical Fruits of Indonesia*. Periplus Editions, Singapore.

———. 1996b. *Tropical Vegetables of Indonesia*. Periplus Editions, Singapore.

———. 1997. *Tropical Herbs and Spices of Indonesia*. Periplus Editions, Singapore.

Jessup, T.C., H. Soedjito, and K. Kartawinata. 1992. *The Proposed Kayan Mentarang Biosphere Reserve: A New Approach to Conservation and Development in East Kalimantan*. Fourth World Congress on National Parks and Protected Areas, Caracas, Venezula.

Johannes, A. 1986. Medicinal plants of the New Guinea highlands: an ethnopharmacologic and phytochemical update. In *Plants In Indigenous Medicine and Diet: Biobehavioral Approaches*, ed. N.L. Etkin, pp. 187–210. Redgrave Publishing Company, New York.

Johns, Timothy. 1990. *With Bitter Herbs They Shall Eat It: Chemical Ecology and the Origins of Human Diet and Medicine*. University of Arizona Press, Tucson.

———. 1994. Ambivalence to the palatability factors in wild food plants. In *Eating on the Wild Side: The Pharmacological, Ecological, and Social Implications of Using*

Noncultigens, ed. N.L. Etkin, pp. 46–61. University of Arizona Press, Tucson.

Kakiuchi, N., M. Hattori, M. Nishizawa, T. Yamagishi, T. Okuda, and T. Namba. 1986. Studies on dental caries prevention by traditional medicines. VII: Inhibitory effects of various tannins on glucan synthesis by glucosytransferase from *Streptococcus mutans*. *Chemical and Pharmaceutical Bulletin* 34:720–725.

Kimball, L.A. 1979. Borneo Medicine: The Healing Art of Indigenous Brunei Malay Medicine. Anthropology Department, Loyola University of Chicago. University Microfilms International, Ann Arbor.

Kuipers, J.C. 1991. Matters of taste in Weyewa. In *The Varieties of Sensory Experience: A Sourcebook in the Anthropology of the Senses*, ed. D. Howes, pp. 111–127. University of Toronto Press, Toronto.

Laderman, C. 1983. Food: belief and behavior. In *Wives and Midwives: Childbirth and Nutrition in Rural Malaysia*, pp. 21–34. University of California Press, Berkeley.

———. 1991. *Taming the Winds Of Desire: Psychology, Medicine, and Aesthetics in Malay Shamanship Performance*. University of California Press, Berkeley.

Lawless, H.T. and H. Heymann. 1999. *Sensory Evaluation of Food: Principles and Practices*. Aspen Publishers, Inc., Gaithersburg, Maryland.

Leaman, Danna J. 1996. The Medical Ethnobotany of the Kenyah of East Kalimantan (Indonesian Borneo). Ph.D. Dissertation (Biology), University of Ottawa, Ottawa.

Lee, C.B. and H.T. Lawless. 1991. Time-course of astringent sensations. *Chemical Senses* 16:225–238.

Leonti, M., O. Sticher, and M. Heinrich. 2002. Medicinal plants of the Popoluca, México: organoleptic properties as indigenous selection criteria. *Journal of Ethnopharmacology* 81:307–315.

Lindemann, B. 2000. A taste for umami. *Nature Neuroscience* 3:99–100.

MacDonald, J.A. 1993. *Floristic Reconnaissance of Ujung Kulon Reserve, West Java, and the Kayan Metarang Reserve, East Kalimantan*. World Wide Fund for Nature, Indonesia Programme, Samarinda.

Martin, Gary J. 1995. *Ethnobotany: A Methods Manual*. Chapman & Hall, London.

McNabb, S. 1990. The uses of "inaccurate" data. *American Anthropologist* 92:116–129.

Nichter, M. 1989. *Anthropology and International Health: South Asian Case Studies*. Kluwer Academic Publishers, Norwell, Massachusetts.

Nielsen, E.S. and I.F.B. Common. 1991. Lepidoptera (moths and butterflies). In *The Insects of Australia: A Textbook for Students and Research Workers*, vol. II, CSIRO, pp. 817–915. Cornell University Press, Ithaca.

Ortiz de Montellano, B.R. 1986. Aztec medicinal herbs: evaluation of therapeutic effectiveness. In *Plants in Indigenous Medicine and Diet: Biobehavioral Approaches*, ed. N.L. Etkin, pp. 113–128. Redgrave Publishing Company, New York.

Oyen, L.P.A. and N.X. Dung, eds. 1999. *Essential-oil Plants*. Plant Resources of South-East Asia, vol. 19. Backhuys Publishers, Leiden.

Pelto, P.J. and G.H. Pelto. 1990. Field methods in medical anthropology. In *Medical Anthropology: A Handbook of Theory and Method*, eds. T.M. Johnson and C.F. Sargent, pp. 269–297. Greenwood Press, New York.

Perry, L.M. and J. Metzger. 1980. *Medicinal Plants of East and Southeast Asia*. Massachusetts Institute of Technology, Cambridge.

Phillipson, J.D. and C.W. Wright. 1991. Can ethnopharmacology contribute to the development of antimalarial drugs? *Journal of Ethnopharmacology* 32:1551–1565.

Pinard, S. 1991. A taste of India: on the role of gustation in the Hindu sensorium. In *The Varieties of Sensory Experience: A Sourcebook in the Anthropology of the Senses*, ed. D. Howes, pp. 221–230. University of Toronto Press, Toronto.

Porter, R. 1997. *The Greatest Benefit to Mankind: A Medical History of Humanity*. W.W. Norton and Company, New York.

Romney, A.K. and R.C. D'Andrade. 1964. Cognitive aspects of English kin terms. *American Anthropologist* 66(3:2):146–170.

Ross, I.A. 1999. *Medicinal Plants of the World: Chemical Constituents*. Humana Press, Totowa, New Jersey.

Rozin, P. 1982. Taste-smell confusions and the duality of the olfactory sense. *Perception and Psychophysics* 4:397–401.

Scott, T.R. and C.R. Plata-Salaman. 1991. Coding of taste quality. In *Smell and Taste in Health and Disease*, eds. T.V. Getchell, R.L. Doty, L.M. Baroshuk, and J.B.J. Snow, pp. 345–368. Raven Press, New York.

Shepard, G.H., Jr. 1999. Pharmacognosy and the senses in two Amazonian societies. Ph.D. Dissertation (Anthropology), University of California at Berkeley, Berkeley.

———. 2002. Nature's Madison Avenue: sensory cues as mnemonic devices in the transmission of medicinal plant knowledge among the Matisgenka and Yora of Peru. In *Ethnobiology and Biocultural Diversity*, eds. John R. Stepp, F.S. Wyndham, and R.K. Zarger, pp. 326–335. International Congress of Ethnobiology, Athens.

Snel, M. 1994. *The Use of GIS as a Tool in the Mangagement of Kayan Mentarang: Creating the Kayan Mentarang GIS Database*. World Wide Fund for Nature, Indonesia Programme, Samarinda.

Sorensen, Kim W. and B. Morris. 1997. *People and Plants of Kayan Mentarang*. World Wide Fund for Nature, Indonesia Programme, London.

Sosef, M.S.M. and S.E.A.J. Horsten. 1999. *Eurycoma* Jack. In *Medicinal and Poisonous Plants (1)*, eds. L.S. de Padua, N. Bunyapraphatsara, and R.H.M.J. Lemmens, pp. 272–274. Plant Resources of South-East Asia, vol. 12. Backhuys Publishers, Leiden.

Speck, F.G. 1917. Medicine practices of the northeastern Algonquians. In *Proceedings of the International Congress of Americanists* 19:303–321. Washington, D.C.

Trotter, R.T. and M.H. Logan. 1986. Informant consensus: a new approach for identifying potentially effective medicinal plants. In *Plants in Indigenous Medicine and Diet: Biobehavioral Approaches*, ed. N.L. Etkin, pp. 91–112. Redgrave Publishing Company, New York.

Turner, N.J. 1988. "The importance of a rose": evaluating the cultural significance of plants in Thompson and Lillooet Interior Salish. *American Anthropologist* 90:272–290.

van Esterik, P. 1988. To strengthen and refresh herbal therapy in Southeast Asia. *Social Science Medicine* 8:751–759.

Weller, S.C. and A.K. Romney. 1988. *Systematic Data Collection*. Sage, Newbury Park, California.

Werner, O. and J. Fenton. 1973. Method and theory in ethnoscience or ethnoepistemology. In *A Handbook of Method in Cultural Anthropology*, eds. R. Naroll and R. Cohen, pp. 537–578. Columbia University Press, New York.

Winzeler, R.L., ed. 1993. *The Seen and the Unseen: Shamanism, Mediumship and Possession in Borneo*. Borneo Research Council Monograph Series, Williamsburg, Virginia.

Wober, M. 1966. Sensotypes. *Journal of Social Psychology* 70:181–189.

———. 1991. The sensotype hypothesis. In *The Varieties of Sensory Experience: A Sourcebook in the Anthropology of the Senses*, ed. D. Howes, pp. 31–42. University of Toronto Press, Toronto.

Wollenberg, E.K. 2001. Incentives for collecting gaharu (fungal-infected wood of *Aquilaria* spp.; Thymelaeaceae) in East Kalimantan. *Economic Botany* 55:444–456.