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Kirsten Jill Tripplett

1999

The Ethnobotany of Plant Resins in the Maya Cultural Region of Southern Mexico and Central America

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The Ethnobotany of Plant Resins in the Maya Cultural Region of Southern Mexico and Central America

by

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Dissertation

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Dedication

Dedicated to my dear grandmother,
Adele Cousins

To Peter Cousins,
uncle and mentor, who taught me to love life and art

and to
Linda Schele
for her inspiration and teaching of Maya cultures
with an open mind and heart

According to the Christian mentality, God has exalted man over all creation but according to the autochthonous religion, the gods are owners of creation and man has only the right to petition them for permission to use it.

—Father Stephen Haeserijn, *Estudio sobre el estado religioso del indigena de Alta Verapaz*

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The Ethnobotany of Plant Resins in the Maya Cultural Region of Southern Mexico and Central America

Publication No.____________

Kirsten Jill Tripplett, Ph. D.
The University of Texas at Austin, 1999

Supervisor: Beryl B. Simpson

The ethnobotany of plant resins within five Mayan ethnic groups in Central America and southern Mexico is documented. The Q'eqchi', Ch'orti', K'iche', Lakandon, and Tzotzil Maya were chosen to serve as cultural focal points from which to assess and discuss salient features and roles of plant resins. Topics addressed include the use of plant resins by the modern Maya, taxonomic sources of plant resins, collections and processing of resins, roles of resins in local or regional economies, presence of Maya resin sources in international trade, as well as functions, roles, and symbolic meanings of resins. The correlation between medicinal uses of resins by the Maya with known medicinal and phytochemical properties of resins found in Western science is investigated. Chemoanalytical analyses were conducted to establish taxonomic identification of resins. Plant exudates are described in K'iche' Maya cosmology, Colonial descriptions by

Spanish and European chroniclers, and are found in the archaeological record; these issues are discussed. The perceived medicinal and ritual properties of plant resins by the five Maya groups are discussed in detail and collection and processing methods described.

Plant resins are critical components of modern Maya medicine and religious beliefs and practices: as fever reducers, wound cleansers, and anti-inflammation agents and as incense and ritual payments in religious rites. Resins are significant sources of cash revenue to collectors and processors as well. Some medicinal folk uses of exudates correspond to former pharmaceutical uses of the same exudates in the industrialized world: as antimicrobial wound cleansers, anti-inflammation agents, and treatments for respiratory illnesses. An extensive reference collection of exudate products was established for chemical and ethnographic investigation. Fourier-Transform Infrared spectroscopic analysis was applied to the collection in order to determine its utility in identification of taxonomic sources of plant exudates purchased in indigenous markets of Guatemala. Two plant taxa, the Pinaceae and Burseraceae, are the most important sources of resins used by modern Maya.

This study is the first to examine the role of plant resins in a modern indigenous culture in the Americas, and provides an interdisciplinary context in which to view these cultural and economically important plant products.

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Chapter I. Introduction

Some time in the 1980s , an archaeological bowl was discovered in Apatzingo (Michoacán), in the Río Balsas basin of Mexico. Within the vessel was a dried, white, amorphous mass believed at first to be ground corn. Using gas chromatography/mass spectrometry to see if any additional substances were present, Castorena *et al.* (1993), determined that the material was a natural resin, derived from *Bursera bipinnata* of the Burseraceae or frankincense family. This bowl is one of several resin artifacts or resinous inclusions found within southern Mexico and Central America, which includes the countries of Belize, Guatemala, Honduras, El Salvador, Nicaragua, and Costa Rica. It is likely that the material was a ritual offering because it is well known from indigenous documents and colonial Spanish records that incense derived from plant resins was a common item in both medicinal and ritual uses just preceding and following the arrival of the Spaniards in the Maya area and the central valley of Mexico. The famous water-filled limestone sinkhole, the Cenote of Sacrifice, at Chichén Itzá in the Yucatán Peninsula, Mexico, contains some of the most striking examples of intact, archaeological plant resins of the Maya. The several examples of plant resins from Chichén Itzá and their continued use exemplify the long association of indigenous Middle American societies with these plant products. Many of these plant resins retain their pre-Columbian names today, and are known variously, as copal, from the Nahuatl term *copalli* (a term now also applied to numerous Asian plant resins), or as *pom*, from several of the Maya languages. While fewer than a handful of anthropologists, archaeologists, and art historians have recently considered the role and functions of plant resins in ancient Maya culture (Freidel, Schele *et al.*

1993; Stross 1994-1996) , no systematic look at modern resin use has been undertaken.

Virtually all literature pertaining to the ancient and colonial Maya of southern Mexico and Central America, especially ethnographies, refer to the use of plant resins as incense or as medicine. Plant resins are frequently sticky, often aromatic substances which exude or can be made to exude from tree trunks, and generally consist of a complex mixture of volatile and nonvolatile chemical compounds. In this study, resin types are defined by the predominant chemical compounds present in the resin material. Based upon this criteria, there are two types of exudates considered here: terpene-based resins and phenolic-based resins knowns as balsams. I use the general term resin to include both resin types, except when distinctions between the chemical constituents are considered important. This study examines wood (xylem) and bark (phloem) resins and balsams, specifically those which exude to the outside of the tree, through human activities, or as a response to other trauma. The potential identification of archaeological plant resins by Castorena *et al.* (1993) using gas chromatography/mass spectrometry led to questions regarding use of plant resins among modern Maya in southern Mexico and Guatemala. Resin technology is a term encompassing the collection, processing, and application of plant resins. Scholarly study of resin technology has traditionally emphasized the industrial applications of resin use in paints, varnishes, naval stores, and so forth, and often neglected indigenous cultural applications. The work of Langenheim and Balser (1975) on the botanical origin of resin objects from aboriginal Costa Rica was the first to apply infrared spectroscopy as an aid in the identification of resin artifacts. While there exists a growing number of studies on the chemical and ecological properties of natural plant resins, few published ethnobotanical studies consider the role of plant resins in cultures. Exceptions to this trend are *Semelai Culture and Resin Technology* (Gianno 1990); *Frankincense and Myrrh: A Study of the Arabian Incense Trade* (Groom 1981); and *The Milk of the Boswellia Forests: Frankincense Production Among the Pastoral Somali* (Farrah 1994). No in-depth ethnobotanical studies of New World resins have been conducted.

What uses are made of plant resins in modern Maya society? This is the primary question addressed in this study. The opportunity to analyze chemically plant resins purchased in the indigenous markets of Guatemala and to study the role of resins in traditional Maya society led to the following questions:

1) Do the medicinal uses of resins by the Maya correlate with known medicinal and phytochemical properties of resins and to botanical sources found in the Maya cultural region?

2) How do chemical analyses contribute to the identification of resin sources?

3) Using five distinct Maya ethnic groups as case studies for resin use

   a) What are the taxonomic sources of plant resins collected, used, and sold by the Maya?

   b) How are resins collected and processed?

   c) What are their roles in local or regional economies?

   d) What is the significance of resins in Maya culture? What are the functions, roles, and symbolism of resins as incense and medicine?

4) How do indigenous uses of resins compare to the use of the same resins in international trade?

The applications of this study are significant. For instance, the study presents, for the first time, a compilation of resins, balsams, and some latex sources in southern Mexico and Central America, including botanical and vernacular names, uses, and supporting literature sources (Appendix 1). This study also provides the first documentation of resin technology and an introduction to associated local economies, among modern and colonial Maya, based upon direct field evidence and a review of the ethnographic literature; and is the first to examine the symbolic roles and functions across several language and cultural groups. It also advances knowledge about plants used by traditional Maya, and explores the correlation between the Maya's perceived medicinal properties of resins and those discovered by modern science (Appendices 2-5). There is enough evidence to recommend the medicinal benefits of these natural substances in the native *materia medica* as effective anti-inflammatory agents in respiratory illnesses, as agents against dermatitis problems, venereal diseases, and as dentrifices. The application of chemoanalytical techniques like Fourier Transform Infrared Spectroscopy to the identification of resins, which allows matching spectra of unprovenienced market samples to be compared with those of positively identified samples, increases our understanding of botanical origins and diversity of resins sold in Guatemalan and Mexican markets (Appendix 2). Spectra obtained from the current study contribute to the growing number of published spectra from economically important resin-producing tree species of the tropics. In sum, this investigation is the first attempt to contextualize plant resins within a botanical and cultural setting in the Americas, by applying taxonomic, phytochemical, historical, ethnographic, and international commerce data, to the issues raised by their uses.

In organizing the material, I deal with distinct subjects, such as the sources of resins, their chemistry, infrared analysis, and ethnography, separately. In Chapter II, *Structural and chemical characteristics of resin exudates*, the anatomical, physical, and phytochemical properties of resins and balsams are introduced. Chapter III, *Infrared analysis and identification of resins from Mexico and northern Central America*, presents the results and discussion based on the analysis of more than twenty resins samples collected by the author in Guatemala and numerous other resins samples provided by various researchers and institutions. Chapter IV, *The taxonomic identity and nature of plant exudates in the Maya cultural region of southern Mexico and northen Central America*, discusses the botanical sources of resins and balsams and their specific phytochemical and medicinal properties. I also consider any pertinent data on the international trade of resinous substances as perfumes and medicines by Europe and the United States in order to demonstrate the long importance of resins still used by Maya today. Chapter V, *Food for the Gods: Uses and Sources of Copal Pom/ Pom/ Copal/ Incense in the Maya Area*, describes the first fieldwork specifically aimed at documenting resin collection, processing, and application, in the Maya cultural region. I examine five different Maya ethnic groups and discuss ethnographic evidence of ritual, cosmological, and medicinal concepts and practices associated with the Maya. In Chapter VI, *Conclusions: The Ethnobotany of Plant Resins and Balsams in Central and Middle America*, I summarize the most salient features of Maya cultural use of these substances. The work presented here is an encyclopedic look at the current status of plant resins in the Maya area. I believe that many stimulating avenues of research in plant taxonomy, phytochemistry, community and population plant ecology, linguistics, economics and trade, and ethnography are generated by these initial findings. Further application of FTIR to Mesoamerican resin artifacts and investigation of the roles of resins in ancient Maya culture is strongly urged.

Chapter II: Structural and chemical characteristics of resin exudates

"Resin" is a nonspecific generic term applied to natural plant exudates that tend to be aromatic and viscous when fresh. In a general sense, natural resins are aromatic, free-flowing, semisoft, amorphous substances exuded from ducts originating within the woody tissue of trees and range in color from white, to yellow or yellowish brown, or red (see Fig. 1). Resins exude either naturally as a result of damage to the bark by various natural agents, or by human tapping, or heating of wood (pyroligeny; Pollard and Heron 1996).

Many plant resins share a class of compounds called terpenes, and consist primarily of volatile oils and larger, less volatile molecules. Balsams, on the other hand, consist of phenolic compounds (including acids) in which simple terpene compounds can be present. Both resins and balsams are discussed here, as they are known to have been important items of trade among the Maya in the past. Plant anatomy and chemistry are important features in the study of resins and balsams because they prepare the way for discussion of the relationships between botanical characters and preadaptations for medicinal use, as well as associated religious concepts. Latexes are another class of exudates used by the Maya. These occur in specialized cellular structures, and while many latexes are composed of polymers of terpenes, thereby sharing certain basic skeletal structures with resins, they are a distinctly different substance, and I address them only superficially.

Much early research was conducted on plant resins and their chemical properties (such as saponification values, acid values, etc.), especially by the Germans, who included many resins in their pharmacopoeia and who had an extensive trade in commercial resins (Dieterich 1901; Mantell 1942; Kopf *et al.* 1942; Howes 1949) Development of analytical tools led to structural elucidation of numerous resinous compounds, and a glance at a list of resins in trade in the early 20th century illustrates the importance, diversity, and diversity of sources of many commercial resins. Attempts to isolate terpenes, improve resin product level and yields through genetic selection, and a better knowledge of phytochemical synthesis, led to intensified research into resin, or terpene, chemistry. Investigations into monoterpenes and their basic chemical units (isoprenes) concerned chemists for years and helped to provide the foundation for organic chemistry. Numerous chemotaxonomic studies of the distribution of terpenoids in plant taxa were conducted in the 1960s through the early 80s (e.g., Hegnauer 1962; Rzedowsi and Ortiz 1988; Rzedowski and Ortiz 1982; Langenheim 1965, 1969; Langenheim and Beck 1968; Langenheim *et al.* 1978; Adams 1989; Lockhart 1990). Much of the older chemical work, especially that of the 1920s to the 1940s, however, generated a confusing array of synonyms and common names, which continues to thwart the nomenclature-conscious researcher today (American Chemical Society 1955). With improved analytical techniques, terpenoid chemistry has become a sub-field in drug synthesis research, especially in regard to anti-microbial and anti-fungal properties, which have applications in both modern and traditional medicine. Numerous products contain terpenes, especially the volatile compounds: cosmetics, soaps, and detergents off all kinds, including shampoos, toothpastes, mouthwashes, air fresheners; they are also common as culinary spices.

A great deal of confusion is associated with commercial names applied to resin types, such as the terms "copals" and "dammars." The terms copal and dammar are used indiscriminately in the older literature and appear to be used as though they were scientific names in a strict sense, rather than as common names. Although copal is reputedly derived from the Nahautl term *copalli*, the term has been, curiously, appropriated to describe a range of resins originating from Old World plant taxa. Langenheim (1990, 1995) defines copals as recent or fossilized resins, extremely hard and with a high melting point, and largely derived from *Copaifera*, *Hymenaea* and other legumes or alternatively, *Agathis* (Araucariaceae) sources[1]. To help avoid errors and confusion in other fields where resins are of increasing importance (e.g., geochemistry and the study of ambers), Langenheim (1995) has recently summarized the common and commerical names of resins and their general botanical sources in an attempt to impose some order upon the proliferation of terms and names. A more comprehensive treatment by Langenheim (in prep.) will be published shortly.

Langenheim (1990) estimates that resins (including balsams) are synthesized in substantial quantities by about 10% of plant families, two-thirds of which are tropical angiosperms and one-third conifers. Resins are lipophyllic, non-cellular, usually water-insoluble and nonconducting substances composed of complex mixtures of volatile and nonvolatile compounds. In terpene resins the proportion of volatile mono- and sesquiterpenes to the nonvolatile diterpenoids determines the vicosity and the rate of crystallization, which in turn controls the rate of flow in impeding the burrowing and blocking of channels (Hodges *et al.* 1979; Schuck 1982; Cook and Hain 1988, Croteau and Johnson 1985, as cited in Langenheim 1994:1248). Upon exposure to air, volatile

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[1] Langenheim explains the use of this term in the commercial literature as restricted to very hard, durable resins with a high melting point, especially to those of the genera *Hymenaea* and *Copaifera* (Fabaceae, subfamily Caesalpinioideae) and various members of the Araucariaceae. See Langenheim (1995:12) for further discussion. Copals in the Maya cultural area range from very soft to very brittle forms. In addition, the most important resins to the Maya are not derived from the taxa cited by Langenheim, and the functions of copal are very different. The commonly accepted industrial definitions of copal contrasts sharply with the Maya cultural definition, which is older by centuries, if not millenia. Tozzer (1941:75, n.338) expounds upon the Colonial use of the term *copalli* and its application to resins and incense in the Yucatán.

components (essential oils) in the resins and balsams may evaporate, or polymerize by oxidation of some larger molecules, resulting in hard, impermeable resin coatings which effectively seal wounds and chemically and physically deter pathogens and herbivores (Langenheim 1973:91). In *Hymenaea* this polymerization may be due to the activity of free radicals in the wood resin (Cunningham *et al.*, as cited in Langenheim 1981:633). Resins are generally water-insoluble (if carbohydrates are present in the resin and are exposed to water, the gums swell, rather than dissolve) and are usually easily dissolved in ethanol, chloroform, and other organic solvents.

ANATOMICAL ORIGIN OF RESINS

While the developmental anatomy of many plant families remains unknown, the wood and secretory structures of the Pinaceae, Leguminosae (Fabaceae), and many Burseraceae, the primary plant resin sources used by the Maya, are fortunately documented, and many of the developmental and biosynthetic processes leading to the chemical structures and their resin products are known. Resins and balsams may originate and are stored in similar anatomical structures but although they may physically resemble each other, their biogenetic pathways are not shared.

The amount (ratio) of constituents comprising the composition of resinous substances can vary from organ to organ, from tree to tree, and from species to species, and population to population. Anatomical structures which both produce and store these materials can occur throughout the plant body, including fruits, shoots, needles, leaves, and roots, and locations vary from species to species. According to Langenheim *et al.* (1978), such differences in composition may be due to developmental changes or may result from different biotic selection pressures.

Resin accumulation can occur in two separate ways, or arise as a combination of both processes. Initially, the substances are synthesized in epithelial parenchyma cells lining rounded pockets, cysts, or elongated canals or ducts and the resin product released into the cysts or canals (Esau, 1965:63) permitting potentially cytotoxic substances to be sequestered. The structures in which exudates are stored can be spherical (cysts) or elongated (ducts), and the composition of resinous material secreted into them can consist of terpenes alone, or both terpenes and carbohydrates, as well as other substances (Fahn 1979:176, see Fig. 2). Schizogenous resin secretion can accumulate in ducts by the separation of the walls of neighboring cells. The process of secretion is not necessarily detrimental. Secretory cells remain alive during secretion, may form long intercellular spaces that may become connected into an intercommunicating system (De Bary 1941, as cited in Esau 1965:63), and may continue to live indefinitely (Fahn 1979:4). Lysigenous secretion arises from the disintegration of cells in the area where the accumulation space develops (Esau 1965: 317-318; Fahn 1979:176) and results in the death of cells (e.g., epithelial cells lining of cysts or pockets). The resin contents may consist of diverse cellular compounds and materials, as in the case of gum resins, which include carbohydrates from the destruction of the cell wall and other cellular organs (Esau 1965:63, 318). Such cavities are increasingly enlarged with continual trauma. A combination of both processes can occur via schizolysigenous accumulation, or the breakdown of entire cells, as in the case of *Hymenaea courbaril* (Langenheim 1973) and *Protium copal* (Webber 1941). Among the neotropical resin sources used by the Maya, the Leguminosae or Fabaceae can yield and store large bodies of resins within the bark and wood. Accumulated masses can become quite large and may exude under pressure to the outside of the tree. Often these exudations are found intact after decomposition of tree and wood (Langenheim 1969:1163).

The most important location of resin-producing structures used by humans are the ducts in the xylem of various angiosperms and coniferous trees (although the specific sources of resins from *Liquidambar* and *Myroxylon* remains unknown by anatomists at present). In the Burseraceae the phloem is the most important source of resins. These ducts can be tapped easily by cutting into the xylem. A critical factor in incision-extraction is to avoid damage to the delicate vascular and cork cambia, two thin layers of tissue just below the bark, and which encircle the entire tree. The vascular cambium gives rise to wood tissues (secondary xylem, or wood, deposited to the interior of the cambium) and to some bark (secondary phloem); the cork cambium produces the bulk of the bark (cork, deposited to the exterior of the cambium).

The issue of constitutive or induced resin production in economically important trees as a response to herbivore or pathogen attack has been addressed in the ecological chemistry literature (e.g., Gershenzon and Croteau 1991; Rosenthal and Berenbaum 1991). Constitutive products are those formed in advance of natural or artificial wounding, while induced products are those formed as a direct result of injury to the bark. As a result of mechanical wounds, many pinaceous trees produce a greater amount of less common monoterpenes in induced resin than exist in constitutive exudates. Such monoterpenes may act as a possible deterrent to pathogen attack (see Langenheim 1994:1248, 1995:3, for a discussion of the significance of these distinctions).

The Chemical Characteristics of Plant Resins

Resinous exudates can be defined chemically based upon their primary constituents: terpene or phenolic compounds. Terpene resins contain mostly terpenes and sometimes smaller amounts of other chemical products (see below). Balsams consist mostly of phenolics and can also contain some low-molecular weight terpenes. Latexes are another type of plant exudate but differ from resins and balsams in terms of their anatomical origin and chemical compounds, and are briefly discussed below.

Terpenes are not restricted to plant resins, but are varied and widespread in nature, and can be found in taxa as diverse as fish, sponges and plants. All plants synthesize and utilize terpenes for primary growth and development (as photosynthetic pigments, steroids, and growth regulators), of which 15,000-20,000 are fully characterized (Langenheim 1994:1224). According to Goodwin and Mercer (1972), there are more individual terpenes than there are any other kind of natural product. Resin terpenesin plants are produced in much greater quantities than compounds with more specific toxic properties (e.g., alkaloids; Thomas 1970:59).

Phenolic-based resins contained within secondary xylem or phloem are composed primarily of phenolic compounds such as phenylpropenoids (e.g., cinnamic acid) or phenylpropenes (e.g., eugenol), acetogenins, fats, and in some cases, traces of amino acids (Langenheim 1995) and can be accompanied by mono- and sesquiterpenoids (Langenheim 1969, 1990, 1995).

Resin secretions have been defined in terms of chemical constituents (e.g., oleoresins, gum resins, resins, essential oils, balsams) and function (i.e., as secondary metabolites with little or nothing to do with primary metabolic processes, and/or as protective substances that deter herbivorous feeding (Fahn 1979:2; see Langenheim 1995). Definitions vary greatly between disciplines, especially in commerce, are often misleadingly used, and require flexible application. Natural oleoresins (as in the pines) are mixtures of terpenes, and usually have a high essential oil content. Depending on the volume of volatile oils present in a resin, the mixture may be fluid, semi-solid, or solid. Gum-resins are resins which contain carbohydrates derived from cell wall breakdown or mucilaginous secretions. Synthetic resins, although similar to plastics, have some of the same characteristics as natural resins, such as nonconductivity but originate from different chemical pathways and are manufactured industrially.

As stated earlier, a predominant class of chemical compounds in resins are the terpenes, which are widespread, natural products. Terpenes are unified by their basic structural units of isoprene molecules, C_5H_8, produced, primarily, by the mevalonic acid pathway (MVA), a secondary metabolic pathway. The initial isoprene structure is then elaborated upon by enzymatic modification to produce a diverse array of configurations. Two isoprene units will condense in a head-to-tail fashion to form monoterpenes ($C_{10}H_{16}$, the basic measuring unit of terpene compounds), three units will form sesquiterpenes ($C_{15}H_{24}$) (Fig. 3), four units will form diterpenes (a double unit of monoterpenes) (Fig. 4) and so forth. Triterpenes (Fig. 4) are formed in a head-to-head fashion from the same terpene precursor as steroids (squalene). The term terpenoid applies to the class in a general sense and is used interchangeably in the literature to indicate compounds derived from the terpene synthetic pathway.

Phenolics, the primary constituents of balsam exudates, on the other hand, are less widespread in nature than terpenes. A particular group of phenolic compounds occur in resins, some produced by the shikimic acid pathway and others from the malonic pathway. Cinnamic acids yield phenolic resin compounds, such as benzoic acid derivatives (see Fig. 5). Balsams are characterized by large proportions of cinnamic or benzoic acids or esters of these acids and often by mono- and/or sesquiterpenes, which provide a liquid phase and additional aromatic notes to the exudate.

A large body of evidence points to the significant ecological properties of terpenes and phenolic compounds. It has been hypothesized that the material found in secretory structures in general, including any resinous and balsamic exudates, serves as a physical and chemical defense mechanism and deterrent to herbivores, demonstrating a rich evolutionary heritage of plant-insect chemical interaction (Fahn 1979:244-245; Mann 1987:130-131, 303-328; Langenheim *et al.* 1981). Langenheim (1994, 1995) provides an excellent discussion of, and introduction to, other terpenes produced in higher plants which have a mediating role within plant populations, terrestrial communities and ecosystems.

Of the exudates in use by modern Maya today, terpene resins appear to be more common than balsams, especially resins from the Burseraceae and Pinaceae. Although two exudate-producing genera are indicated as historical sources of exudates, *Hymenaea courbaril* (Fabaceae) and *Liquidambar styraciflua* (Hamamelidaceae), neither has been definitively identified by the author in in the markets of Guatemala, nor in chemical analyses of purchased exudate samples. It is suspected that these two genera are in use, at least in some areas of Guatemala, and that their absence is an artifact of sample size.

Mono- and sesquiterpenes

Monoterpenes are most widely recognized as constituents of the Pinaceae, Myrtaceae, Rutaceae, Lamiaceae, and Asteraceae (Lerdau and Gershenzon 1977), although they have been found in over 50 different families of higher plants (Banthorpe and Charlwood 1980). A given monoterpene or sesquiterpene can be present in a family, but not in all genera, and not within all species of a genus. Plant-derived mono- and sesquiterpenes have a relatively low molecular weight ($C_{10}H_{16}$, and $C_{15}H_{24}$), are usually in a volatile, liquid state and are aromatic, giving natural resins their characteristic odors. The volatile fractions of resins which can be separated from higher terpenes are frequently called essential oils. Mono- and sequiterpenes are found not only as components of essential oils and resins (including phenolic resins), but are thought to be ubiquitous throughout higher plants and present as trace metabolites that volatize inconspicuously or are turned over metabolically (Charlwood and Banthorpe 1991). They can usually be obtained through steam-distillation of plant material, although some monoterpenes may also be present in non-distillable forms (Lerdau and Gershenzon 1977). Many mono- and sesquiterpene structures exist, and can be oxygenated with alcohol, ketone and ester groups. Both mono- and sesquiterpenes serve as solvents for di- and triterpenoids, which are usually solid at room temperature (Mills 1977; Langenheim 1990). More than fifty basic skeleton types have been discovered in the sesquiterpenoid class and many possess antifungal, antibiotic, herbicidal, and antitumoral properties. Both mono- and sesquiterpenes can be present in the same resin or one can occur without the other.

Di- and triterpenes

By virtue of their greater complexity and larger molecular structures, diterpenoid (C_{20} H_{32}) and triterpenoid ($C_{30}H_{48}$) groups possess a heavier molecular weight, are less volatile, less aromatic, and more solid than mono- or sesquiterpenes. They often have a high essential oil content. These groups are associated with specific plant taxa and are generally not found together in the same species (Langenheim 1995; Mills, 1977; Ponsinet *et al.* 1968:287) and only occasionally in the same tissues

(Nicholas 1964; Graebe *et al.* 1965; Goodwin 1965; as cited in Ponsinet *et al.* 1968:289). For instance, diterpene resin acids are characteristic of the Pinaceae and the Caesalpinioideae, a subfamily of the Fabaceae (Leguminosae). Resins from some leguminous taxa are sometimes referred to as "hard" resins, because they are characteristically solid, and usually lack high essential oil content, in contrast to balsams or oleoresins. Triterpenoids are characteristic of the Anacardiaceae, Burseraceae, and Dipterocarpaceae (the latter is an Old World family and not considered here). Terpene resins are typically complex, and have a wide array of possible functional groups, such as alcohols and acids (aldehydes, ketones, esters, and carboxylic acids). Di- and triterpene resins can also contain a number of monoterpenes, sesquiterpenes, linear polyterpenes and aromatic ester type compounds (Thomas 1970:65). For instance, *Hymenaea courbaril* trunk resin is characterized by diterpene resin acids accompanied by sesquiterpenes (Martin *et al.* 1971); Langenheim 1973, Langenheim 1981, Table II, 1995, Fig. 3). *Pinus* contains diterpene resin acids with both mono- and sesquiterpenes. Di- and triterpenoids found within plant resins fall into several major groups, dependent, in part, upon the number of rings found within any particular skeletal structure. Diterpenoids, for example, often consist of acyclic, cyclic, bicyclic, and tricyclic structures, some of which possess interconvertible, conjugated double bonds.

Phenolics in balsams

A list of the distribution and chemical structures of phenolic compounds found in plant resins, according to family, genus, or species, is not readily accessible, and no printed summary was encountered during the literature search. James Duke's Ethnobotanical Database (Duke 1998), hosted on the World Wide Web by the United

States Department of Agriculture (http://probe.nalusda.gov:8000/related/aboutethnobotdb.html), is a highly valuable venue for assembling a list of plant genera according to a number of criteria: by specific chemicals (e.g., cinnamic, benzoic acids), by disease, and other configurations. The site has some limitations however. Chapter III provides summaries of the terpene and/or phenolic constituents of resin-bearing tree species used in the Maya region.

Differences between latexes and resin and balsam compounds

Latexes differ from resins in several ways. Latexes, which occur in cellular structures called laticifers, are found in more than 12,500 species in 900 genera and about 20 plant families (Van Die 1955; Metcalfe 1967). The cellular structures of laticifers are heterogenenous, as are their development and metabolism between genera. Although some latexes share certain chemical features with resins, they are a very diverse class of compounds, containing terpenes, carbohydrate, alkaloids, proteins, and more. The exudate can be milky, white, clear, yellow, or red, or other colors. There are elastic and non-elastic latexes as well. Triterpene resins, accompanied by a number of monoterpenes, sesquiterpenes, linear polyterpenes and aromatic ester type compounds, can form a large or predominant component of latex (Thomas 1970:65). The reader is referred to Fahn (1979:223-244) and Esau (1965:308-334) for in-depth discussions of latexes and associated cellular structures. Some latexes, including those of the Apocynaceae, Clusiaceae, Moraceae, and Sapotaceae, contain compounds which are useful as insecticides. While important latexes have been included in the list of resin sources (Appendix 1), they are listed largely because I wish to demonstrate that exudates *in general* are important plant products, (not just resins or balsams), and because latexes were so obviously important at the time of the Spanish arrival.

Chapter III: Infrared analysis and identification of resins from Mexico and Central America

INTRODUCTION

This chapter focuses on the analysis and identification of Mexican and Central American resins and balsams, collected by myself and others, using Fourier Transform Infrared Spectroscopy (FTIR). FTIR techniques were used to analyze twenty four exudate samples from identified plant sources; these spectra serve as a "baseline" against which unidentified exudate samples were compared. Twenty four unidentified natural plant exudate samples were purchased in Guatemalan markets by the author, known only by their vernacular name. More than half of these samples were then analyzed and compared to the identified resin spectra. The analytical component was conceived as a result of work by Gianno (1990), in which Malaysian tree exudates were analyzed using infrared spectroscopy (IR) in an anthropological context. IR was initially applied to the study of resins in the mid 1950s (Feller 1954). Several researchers (Beck *et al.* 1964; Langenheim and Beck 1965; Langenheim 1969; Langenheim and Balser 1975), explored the application of IR in the identification of amber (fossilized plant exudates) and modern exudate sources. The presence of certain stable constituents in amber made it possible, in many cases, to generate spectral "fingerprints," which were correlated with infrared spectral patterns of modern resins, and whose taxonomic sources were known. Consequently, the taxonomic sources of the ambers were identified. Resins are complex mixtures of relatively high-molecular weight molecules, and despite time and depositional processes, all simple functional groups are preserved, except carbon-carbon double bonds, and the skeletal frequencies are dampened but not extinguished (Langenheim 1969:1159). One major limitation to IR analysis of resins exists: Only the major structural groups can be expected to yield strong absorption bands. The presence of similarities between known and unknown resin sources strongly indicates shared structural constituents (Langenheim 1965, 1969:1159). Definite botanical identities were made by Langenheim, using concomittant evidence (e.g., floral parts). Further identifications of amber sources have been made (e.g., using X-ray diffraction analyses, pyrolysis-mass spectrometry, and pyrolysis gas chromatography/mass spctometry, and ^{13}C NMR and other methods, as cited in Langenheim 1995).

FTIR was used to generate fingerprints of economically important resins from the Maya region of southern Mexico and Guatemala. In the course of the present study, it was found that some of the unknown sources of resins clearly show similarities to identified sources, while two samples do not resemble any available identified samples.

The interpretation of infrared spectroscopy (IR) is based upon the correlation of absorption bands in the spectrum with the known frequencies of covalent molecules, including stretching and bending of their bonds. When absorption bands from an unknown substance are compared to those of a known substance, one can directly compare the two, and establish whether the substances are identical or not. The utility of IR in ethnobotanical studies of Malaysian resins was recently demonstrated by Gianno (1990). In addition, differences between trunk resin composition can be found within species, reflecting differing composition or proportions of exudate constituents between individual trees and populations. Physiologic differences between populations may arise in response to different biotic pressures. Again, the chemical identities of the resin molecules are not being sought in this study, only the fingerprint spectra of the resin samples, in order to aid the determination of taxonomic sources of unknown resin samples. Initial infrared studies can be followed by more definitive tests (especially in collaboration with chemists).

METHODS

Twenty four plant exudate product samples were collected in the markets of ten different towns in the Central American country of Guatemala by the author. Common names, uses, and other cultural data were collected whenever possible. The samples and associated data are presented in Table 3.1. Sixteen of the samples were qualified to be analysed using FTIR. The other eight samples were represented by composites of leaves, bark, and/or tree exudates (*copal negro*), aromatic wood chips (e.g., *mirra*), or highly resinous wood (*ocote*). Any of the exudate samples that were found to be soluble in organic solvents like chloroform and ethanol were then submitted to FTIR analysis.

Unidentified and identified exudate samples were analyzed and FTIR spectra generated on a Nicolet Avatar 360 FTIR unit in the laboratory of Dr. C. Grant Willson, Chemistry Department, The University of Texas at Austin. FTIR samples were prepared using approximately 0.5-1.0 mg or less of exudate material (crushed in an agate mortar) and approximately 75 to 90 mg KBR (potassium bromide). These were mixed together and a pellet produced using a pressure-generating die. Spectra were analyzed with EZ Omnic software on percentage transmission setting. A complete list of identified samples are listed in Appendix 2.

Dr. Jean Langenheim, of the University of California at Santa Cruz, contributed ten identified resin samples. All were collected in Chiapas, Mexico, in the 1960s. The Royal Gardens at Kew and the Field Museum also provided valuable resin samples. Several samples from Kew were collected in Mexico and one from Guatemala. Many of the samples from the Field Musem were collected and displayed at the 1893 World's Columbian Exposition in Chicago and are given only common names. Most of the Field Museum samples are from South America, and therefore not relevant to the discussion here. Unfortunately, none of the samples from Kew or the Field Museum have corresponding voucher specimens, lending some doubt to their identity. Andrea Weeks of The University of Texas at Austin provided me with two vouchered *Bursera* resin samples for use in this study. Two North American taxa (*Taxodium* spp., Taxodiaceae, and *Picea* spp., Pinaceae) were collected by the author and are included as records of additional plant resin spectra. Four incense samples from Mexico City, Mexico, and one from Austin, Texas, were also submitted for analysis. The resins whose sources were known served as the references by which all unknowns were compared. These exudate samples are listed in Table 3.1.

The spectral analysis of all taxonomically identified and unidentified exudate samples are presented below. Each sample was compared to all others. Important absorption peaks characteristic of each sample are discussed and compared to other samples in the results section. Comments on the source and spectra are given as well.

Table 3.1 Resin samples analyzed with Fourier-Transform Infrared Spectroscopy. Column 1 consists of identified resin samples and collection number. Column 2 consists of resins whose sources have been identified by collectors, but all lack corresponding voucher specimens to confirm their true identity. Other resin samples submitted to FTIR are located in Appendix 2.

Column 1	*Column 2*
Postively identified resins/collection number	**Collection number and reputed scientific or common names of herbarium or personal samples, and country of origin, when known**
Bursera bipinnata JHL 4797	*Bursera copallifera* (= *Bursera jorullensis*), KT 24, Mexico
Bursera bipinnata AW98-vii-16-1(a)	*Bursera excelsa*, Field 16173, Mexico
Bursera heteresthes AW98-vii-15-4	*Bursera excelsa*, Kew 64826, Mexico
Protium copal KT26	*Bursera graveolens*, Field 38, Mexico?
Hymenaea courbaril JHL 4861	*Hymenaea courbaril*, Kew 59751, Bahia, Brazil
Hymenaea courbaril JHL 4778	*Liquidambar styraciflua* Kew 56922, Guatemala
Pinus montezumae JHL 4779	*Pinus caribaea*, Kew 27872, Cuba
Pinus oocarpa JHL4757	*Protium aracouchii*, Kew 63381, South America
Pinus psuedostrobus JHL 4761	*Protium guinense*, Kew 63882, British Guiana
Pinus strobus var. *chiapensis* JHL 4777	*Protium* spp., Field 11, Mexico, "copal blanco"
Pinus tenuifolia JHL 4683	*Taxodium* spp., KT 25, Texas, U. S. A
Pistacia mexicana JHL 4873	*Picea* spp., KT 26, Maine, U. S. A.
	"Copal blanco," Bye 2, Burseraceae, Mexico
	Commercial Mexican frankincense, KT 24, Burseraceae, Mexico

JHL= sample number from exudate collection of Dr. Jean Langenheim, University of California

Field= sample number from exudate collection of the Field Museum of Chicago

Bye= sample number from exudate collection of author and whose geographical origin was tentatively identified by Dr. Robert Bye, Jardín Biológico, Mexico City, Mexico

KT= sample number from exudate collection of author

RESULTS

Results from the current study indicate that FTIR can be very useful in attributing resins to the level of plant family, if not genus. Occasionally, spectra were found to match each other almost exactly. Chemical analysis suggests that the primary sources of plant exudates commonly sold in Maya markets in highland Guatemala are from the Burseraceae and the Pinaceae. The spectrum from *H. courbaril* is problematic, however, because it is very similar to *Pinus oocarpa* (each sample was re-analyzed to verify this finding). This issue requires further attention and resolution.

The Pinaceae displays a great deal of heterogeneity between species. Such variation in chemical composition and proportion is supported by the findings of Mirov (1967) and others (Zavarin 1968), who found that quantitative differences exist between the chemical constituents of pine resins and can be useful chemotaxonomically. The Burseraceae is also an important source of exudates used as incense and medicine, and displays some evidence of possessing family attributes, or characteristic spectral patterns. Langenheim (1969:1161) found species complexes in *Bursera* and *Protium* based upon their terpene constituents. Rzedowski and Ortiz (1988) analysed the resinous exudate of *Bursera* species (using gas-liquid chromatography) as a means of examining chemotaxonomic variation between species and species hybrids.

Figure 6 presents spectral "fingerprints" from identified samples representing five different plant families; Burseraceae (*Bursera bipinnata)*, Fabaceae (*Hymenaea courbaril*), Anacardiaceae (*Pistacia mexicana*), Pinaceae (*Pinus oocarpa*), and *Liquidambar styraciflua*). As one can see, the waveband portion of the spectra from 4000 cm-1 to about 1250 cm-1 are similar, due to similar structural components, but the remaining peaks in the spectra are distinctive. The finer differences begin to appear from about 1200 cm-1 to 600 cm-1 (Fig. 7), the "fingerprint region" for plant resins (Langenheim and Beck 1965) as I shall demonstrate below.

As a specific example of my analytical technique, Figure 8 compares spectra from two distinct taxa, *Bursera bipinnata* (Burseraceae) and *Pinus strobus* var. *chiapensis* (Pinaceae). Both are known to be important sources of resins in southern Mexico and Guatemala. The two specimens share similar peaks around 1465 and 1386 cm-1, respectively, but begin to diverge shortly after (more apparent in the close-up spectrum). The sharing of broad peaks at about 3400 cm-1 indicates the stretching of bonds in alcohols and/or carboxylic acids, and is confirmed by the presence of peaks at 1700 ± 100 cm-1, indicating the stretching of C=O (carbonyl) bonds (these peaks display a great deal of variation in shape and intensity between samples). At 2930, there is a shared peak corresponding to stretching C-H bonds. Absorption at 1465 and 1385 (±) indicate the bending of those same bonds. There are typically few bands found between 2000-1800 cm-1. A weak peak at 1650 cm-1 may indicate a C=C bond, and a small peak around 1100 cm-1 would indicate a C-O bond, but is apparently lacking in the *Bursera* sample, and is represented by only a minor peak in *Pinus*. As can be seen, absorption peaks in the upper region of the spectra begin to differentiate. This is the area of greatest interest in distinguishing resins from one another. For instance, Spectrum 2b provides details of the region. While there is a rough correspondence between peaks at 1242 cm-1, 1151, and 1036 cm-1, no further bands are clearly shared, except, perhaps, at 900 cm-1. The region between 1200 and 1000 cm-1 corresponds to C-O bonds and both samples possess such bonds, but the intensity and shape of the peaks are stronger in *B. bipinnata*. Distinctive differences begin to appear in the 1200-1000 cm-1 zone. In the closeup spectra small but clear peaks are found in *P. psuedostrobus* var. *chiapensis*, whereas *B. bipinnata* lacks them, but possesses a peak at 1050 cm-1, which is lacking in the pine species. Some peaks occur in the 950-825 cm-1 region in *Pinus* and the signal becomes weaker in the uppermost region. The region beween 1000 and 650 cm-1 is generally where bending C-H bonds appear. Aromatic bonds also bend in the region between 900 to 690 cm-1, with corresponding peaks in the lower region of the spectra, at 3150 to 3050 cm-1. There are enough differences in peak signals and intensities between identified exudate samples to begin recognizing patterns typical of a family, genus, and an occasional species. These patterns can allow comparison and tentative identifications of unknown samples.

Some comparisons are problematic and identification is unresolved. For example, several exudate samples collected in western highland markets were found to be mixtures (e.g., sample KT 18 is made from the resin of *Pinus* spp., chopped pine needles, and oak leaves (*Quercus* spp., Fagaceae). The mixture is, in fact, cooked together, and it is virtually impossible to isolate the resin exudate from the wood and leaf tissue. Other mixtures are not so thoroughly mixed together. Less common in the markets is an exudate form (Sample KT 12, Fig. 9) composed of what appears to be two kinds of material, the first of which consists of two different sizes of the same or a similar resin, in large glass-like shards and small cubes of a yellow, translucent, and very hard exudate. This first material bears a strong resemblance to other exudates (e.g., KT 5, Fig. 9) sold separately in the region. The second substance within the sample consists of very small, brown pieces of exudate with woody inclusions. These smaller pieces do not resemble any other resins I have seen in Guatemala, although they may merely be organic litter from the collecting process and thus share the same botanical origin. I remain puzzled by the second part of this mixture. When the first component was analyzed, it was found to most closely resemble *Pinus caribbea* (Kew 27872) (Fig. 10), especially in the upper region of the spectra (Fig. 11), with minor differences in peak shape and intensity. An additional problem of this component of sample KT 12 is that it may have been heated and then cooled. Alternatively, the resin may have been allowed to flow into a container and removed from it later. As stated previously, the first component, the yellow resin, was frequently seen sold by itself in chunks ranging from the size of a fist, to small bits mixed with crushed powder of the same. When sold in this fashion, the resin clearly showed signs of molding, as if from a huge baking pan. No organic matter was found in any these purchases and the resin was quite translucent, brittle, and hard, like glass. When broken into smaller pieces, it quickly lost its shape and fell into sharp pieces, or fine powder. Collecting and cooking the resin would be consistent with processing data gathered from one copal maker in the area, but the spectra would be likely to reflect loss of volatile oils and some polymerization. The peaks in the O-H region could be interpreted to mean that some loss of volatile compounds occurred as a result of heating. Only a light fragrance note was detected at the time of purchase. Samples of *Hymenaea* resins (e.g., Langenheim and Kew), however, resemble KT 12 strongly, and these samples appear to be flow resins, that is they are exuded by the tree in large, clear flows. Other samples, with similar physical characteristics, notably KT 5, and KT 22 (Fig. 12), matched each other very closely, except in the 1300 to 1200 cm-1 region, where KT 22 displays a broad peak, possibly indicating a greater quantity of alcohols, carboxylic acids, or esters in the sample. Interestingly enough, these resins are physically like resins from Mexico and South America, and whose sources are identified as *Hymenaea*. Further analysis is necessary in this instance, but this is an exceptionally difficult sample.

Analysis of spectra of unknown exudates from Mexico and Guatemala

KT 1 (Fig. 13). "Estoraque" was the name given to this sample by the vendor when it was purchased. "Estoraque" is the common name historically given to *Liquidambar styraciflua*, according to colonial period reports. Estoraque has a long historical presence in the various ethnographic literature and colonial Spanish reports, but it has been difficult to locate any recent published ethnographic uses for, or chemical analyses of, the balsam. Based upon the long association of the common name with the taxon *Liquidambar styraciflua*, it was thought that KT 1, if it were indeed from *L. styraciflua*, would be found to most closely resemble Kew 56922, reported as *Liquidambar styraciflua*, but this turned out not to be true generally, except in regard to some specific peaks (Fig. 14). The exudate of *L. styraciflua* is technically a balsam, and comprised primarily of phenolic compounds. Strong, characteristic phenolic peaks were expected in the uppermost region of the spectrum of KT 1. There are strong peaks but the signal is not well differentiated (Fig. 15). In contrast, Kew 56922 displays strong, clear peaks corresponding to phenolic constituents. While there are certain peaks in agreement with each other, a number of the peaks found in the Kew sample are lacking in the KT sample, or do not correspond exactly with each other, especially in the region from 800 cm-1 and onward. In this region small but distinct bands are present and shared at 750, 700, 650, with inverted peaks shared at 675, and 725. According to Langenheim and Beck (1965), a distinctive pair of peaks at 750 and 700 cm-1 indicate monosubstituted benzenoid rings, such as cinnamic acids and styrene, associated with amber thought to be from *Liquidambar*. The notes accompanying the Kew sample are incomplete, and lack locality data or any other detail that might provide further information as to plant source or geographical origin. There are at least two reasons for the contrast between samples: one, the contrast may be attributable to chemical differences between individuals, or two, the estoraque sample purchased in the market was not from *Liquidambar styraciflua*, but from some other exudate-bearing taxa altogether. The woody tissue accompanying this sample was determined by Dr. David Arnold, at The University of Texas at Austin, to be of angiosperm origin.

KT 2 (Fig. 16). KT 2 and KT 20 were purchased in different towns in the Kiché-speaking region of the Guatemala highlands, Totonicopán and Momostenango. KT2 was identified as a medicine by the vendor, while KT 20's function was identified as copal, or incense. The towns are relatively close to each other and share similar vegetative elements, primarily pine-oak forests. The two samples resemble each more closely than they resemble any other sample and are virtually identical (Figs. 17, 18). They are likely to have been collected from the same species, yet match none of the identified resin specimen spectra. A broad double band is located between 1455-1375, and more major ones at 1082 and 1034. Other determining peaks are found at 880, accompanied by a sharp inverted peak at 810, 770, 715, and 610 cm-1. The woody tissue accompanying this sample was determined by Dr. David Arnold, at The University of Texas at Austin, to be of coniferous origin. Further comparison with a wider range of resin specimens is needed.

KT 3 (Fig. 19). The vendor from whom this sample was purchased stated that the "source of this copal is not from Guatemala." The sample consists of granular, sugar-like globules, with a slight reddish color. No signs of bark or organic matter are included which might aid in identification. The spectra is atypical of a terpene resin: it lacks a distinct carbonyl band between 1820-1660, and has a broad, strong absorption peak between 3562-3340, indicative of OH bonds and phenolic compounds, which is confirmed by C-O bands between 1300-1000 cm-1. The weak C=C absorption at 1650 implies the presence of an aromatic ring, confirmed by aromatic C-H bands to the left of the 3000 cm-1 absorption area. It is probably the aliphatic CH which occurs to the right of this demarcation, at 2942 cm-1; a series of very small peaks may indicate an aldehyde band. KT 1 and Kew 63882 appear to be similar to KT 3 at first glance, but both possess carbonyl peaks. Similar peaks are present in samples of *Taxodium* spp. and *Picea* spp. collected in Texas and Maine, respectively. The *Taxodium* sample (Fig. 20) lacks a distinctive carbonyl band and is in agreement with many of the peaks of the upper region and particularly with the OH band at approximately 3300 cm-1. The aliphatic C-H band between 3000-2900 is very strong and moderate in width and is accompanied by a small band which may indicate an aldehyde. The *Picea* sample (Fig. 21) possesses a carbonyl band, with a small, possible aldehyde band similar to *Taxodium*. Both genera contain terpene resins. It is suspected that KT 3 represents another Mexican or Central American plant resin source not yet collected and identified.

KT 4. This resin sample was again collected in the highlands. The informant suggested that the term copal criollo (which generally means "of native origin") "is the best," perhaps indicating a local or at least regional origin. The sample consists of yellowish, waxy, rounded globules. A vendor in Chichicastenango later said that this incense "has the best odors." KT 4 resembles the spectra of KT 24 (Figs. 21, 22), commercial incense from Mexico, identified by the packagers as *Elaphrium jorullense* (=*Bursera jorullense* = *B. copallifera*; Rzedowski and Guevara-Fefer 1992:14). The match is a good one, and clearly shows the utility of comparing resin samples using FTIR spectroscopy. Admittedly, the putative source of KT 24 may not be a reliable one, but the correlation between the sources, at least, is clear. *Bursera copallifera* is common in central and southern Mexico. The peaks of particular interest in the upper region are 1456, 1378, 1243, 1048, 884, 825, 775, and a very minor peak at 715 cm-1. The spectra did not correlate with any of the other Mexican *Bursera* species in the present resin collection.

KT 5. Copal amarillo is a deep yellow, translucent, and very hard resin purchased in the western highlands of Guatemala. It was found to match *Pinus caribaea* (Kew 27872) very closely (Figs. 23, 24). KT 5 matched the Kew resin at bands 1460,1385, 1273, 1182,1150, 1040, 990, a broad peak at 950, 815, 690, 660, and an inverted peak at 840. Some noise is present at the upper end of the Kew 27872 spectra which is absent in the KT 5 sample. KT 22, identified as a *Pinus* species, also bears some resemblance to KT 5 but matches the Kew sample more closely. *P. caribaea* is not a local pine species and is distributed mainly in lowland coastal plains, growing under frost-free conditions, thus barring it from the western highlands (Perry 1991; Farjon *et al.* 1997). The closest populations in Guatemala are in the uppermost reaches of Alta Verapaz, and the lower Petén , indicating interregional trade.

KT 8 (Fig. 25). This sample consists of small and dark to light yellow grains and lacks any organic matter. The spectra was found to be in general agreement with *Pinus oocarpa* (JHL 4757) (Fig. 26). Very clear, strong peaks are found at 1459, 1385, 1247, 1180, 1037, 909, 823, 706, and 650 cm-1 in KT 8. All of these peaks but the very last are shared with the spectra of *P. oocarpa*. This species is found in large stands in the highland region of Guatemala (Perry 1991). The presence of a carbonyl band at 1695 indicates that the sample is a terpene resin.

KT 9 (Figs. 27, 28). KT 9 is puzzling because it superficially resembles KT1, estoraque, but the density of the wood is much less than that of KT 1. The surface of the sample is hard and shiny, with few resinous protuberances, as though dipped in resin, and its fragrance is much lighter and less "piney." Numerous bands are present in the upper region: 1455, 1379, 1199, 1173, 1137, 1047, 1041, 991, followed by a series of small, but distinct, peaks and inversions between 975 and 900, a major band at 875, and a wealth of other small peaks, including a sharp inverted peak at 800, all through the rest of the upper region. The spectra of KT 9 may correspond to a phenolic IR signature, but it also seems to fit into a general burseraceous pattern (Bye 2, Burseraceae, Figs. 29, 30). The woody tissue accompanying this sample was determined by Dr. David Arnold, at The University of Texas at Austin, to be of angiosperm origin. Further analysis is needed.

KT 12. The analysis results for this sample were reviewed above at the beginning of the *Results and Discussion* section. *Pinus oocarpa* or *Hymenaea courbaril*.

KT 13 (Figs. 31, 32). Purchased in Tecpan, this sample physically resembles KT 4, copal amarillo, but no name or infomation about the source could be obtained from the vendor. The town itself is a routine stop for trade and commerce in the highlands. The spectra shares some of the major peaks of KT 4 but the uppermost region is comparatively smooth, and only very small, but perhaps significant, bands occuring at 880, 800, 750, and 620 cm-1; somewhat similar peaks are found in KT 4 and the commercial incense sample discussed above. These peaks are much more visible in the complete spectrum of KT 13 than they are in the closeup of the upper region. A burseraceous source may be tentatively suggested for this resin sample.

KT 16 Figs. 33, 34). This resin sample was collected in southeastern Guatemala, in Chiquimula, close to the Honduran border. The altitude in the area ranges from 150- 2100 meters above sea level. The region possesses both pines and members of the Burseraceae, two important potential resin sources. According to an ethnographic report (Wisdom 1940), the Ch'ortí Maya of the department utilize a burseracous source for their copal incense. KT 16 does not resemble any of the resins from this plant taxa, nor does it match any other known or unknown resin samples except *Pinus caribaea* (=*P. caribaea* var. *hondurensis*, Kew 27872) and actually differs in only two regions, at bands 960-940 and 900-860. A resin sample from the pine population in and around the Chiquimula region may yield a closer match; Kew 27872 is from a Cuban population of *P. caribaea* var. *hondurensis*.

KT 20 (Fig. 35). See discussion of KT 2 above.

F 38 (Fig. 36). F 38 is designated as *Elaphrium graveolens* (=*Bursera graveolens*) by the collector. Its primary peaks in the fingerprint region are 1458, 1387, a broad band at 1238, 1036, 889, and a minor peak at 630 cm-1. The spectra did not resemble any of the identified resin samples, but did resemble Kew 63882, designated as *Protium guianensis*, and collected in British Guiana, and used as incense. Further analysis with dependable samples from *B. graveolens* could illuminate the tentative identification of F 38. On the other hand, a close resemblance between Kew 59751, *Hymenaea courbaril* (Figs. 37, 38), was also detected. This sample was collected in Brazil, however, and displays differences in bands in the 1200 and 600 cm-1 region and onward.

A closer look at the spectra of identified resins

In this section I briefly present and discuss the different spectra of *Hymenaea courbaril*, *Bursera*, and *Pinus* species. Many of the *Bursera* and pine spectra have not been published before, nor differences examined. A brief introduction to spectral differences between *Bursera bipinnata* and *Pinus strobus* var. *chiapensis* are given above.

The two *Hymenaea* spectra (JHL 4861, 4778, Fig. 39) are from resin samples of different individuals and were collected in Chiapas, Mexico, by Dr. Jean Langenheim in the 1960s. Curiously, they contrast most prominently in the O-H region (around 3000 cm-1) and in the region between 2700-1900 cm-1, where the absorption band of one is wide and inverted, and wide and convex in the other. The closeup of the spectra provides better detail of the minor differences between the samples. The major constituents agree with each other, but there are numerous tiny peaks in JHL 4778 that are lacking in JHL 4861, and which become somewhat muted in regard to the peak at 600 cm-1. I cannot yet account for these differences, and they may be a result of a too-heavily concentrated FTIR sample.

All samples from the Burseraceae were analyzed; these samples include both the provenienced samples, as well as several others whose specific identity is unknown, but attributed to that family by collectors. A comparison between seven samples are presented in Fig. 40. The spectra are stacked, one upon the other, permitting a broad examination of the main bands important to each. Two samples of *Bursera bipinnata* in the present resin collection, samples JHL 4797 and AW98-VII-16-1a, were analyzed (Fig. 41). Although there are some slight differences in the intensity of peak shapes between the samples, they are quite similar until the region above 880 cm-1. The contrast in bands in this region may be due to differences in age of the resins—JHL 4797 is over thirty years old, and AW98-VII-16-1a was collected in 1998—and some loss of volatiles and polymerization may have occurred in the older sample. At the top of the figure I have contrasted the of the two preceding spectra with that of *Bursera heteresthes*, whose spectrum is smoother, with broader peaks, and is distinct from *B. bipinnata*. Field 38, *Bursera graveolens* (=*Elaphrium graveolens*) can also be distinguished from other species in the genus. Copal blanco

(Bye 2; confidently attibuted to the Burseraceae by Robert Bye, pers. comm.) and *Bursera excelsa* (F 16173) are strikingly similar (Fig. 40) and it is confidently suggested that the Bye 2 sample is derived from *B. excelsa* or from the same *Bursera* species source. F 11, copal blanco, differs in some details from F 16173 (*B. excelsa*), notably in the intensities and widths of bands between 1200-1100, but these differences may be insignificant. A comparison of the two different samples of *B. excelsa*, that from Kew (Kew 64826) and the Field Museum (F16173) yields significant differences in the upper region of the spectra. There is agreement between the spectra in the lower region but a multitude of tiny, undifferentiated peaks in the Kew 64826 spectrum, begins at about 1000cm^{-1}, and the signal ends before the 600 mark. No modern collections of *B. excelsa* were available for analysis for further testing.

The spectrum for *Protium copal* (Burseraceae) is presented (Fig. 42). The sample was purchased in Lanquín, Alta Verapaz (eastern Guatemala), directly from a copal collector. According to my informants in the area, *Protium copal* is the only tree exudate collected for use as incense or as medicine in the community and surrounding areas. The major peaks in the spectrum occur at 1700, 1456, 1385, 1050, 1005, with some good differentiation in the uppermost region, between 900 and 500 cm^{-1}. *Protium copal* is clearly distinct from the *Bursera* species in Figs. 40 and 41, especially from the 1100 cm-1 band and upwards. Langenheim found discernible species complexes in *Bursera* and *Protium* during the course of her studies (Langenheim 1969:1161). An in-depth study investigating these complexes could lend interesting data to the taxonomic and phylogenetic relationships between the two sections of *Bursera* in Mexico (section *Bursera*, or "cuajiotes," and section *Bullockia*, "copales;" see (McVaugh and Rzedowski 1965; Becerra 1997, 1999), well as relationships within the *Protium* taxa.

One resin exudate sample, purportedly from *Protium guianense* (Burseraceae) and contributed by Kew (Kew 63882), is a South American taxa, and not therefore, not technically included as one of the identified Mexican or Central American plant exudates in this study. Its spectra is, however, presented here (Fig. 43) and then contrasted with the spectra of *Bursera graveolens* (Field 38, Fig. 44), in order to show the possibility that a burseraceous "fingerprint" may exist. Some major chemical compounds appear to be shared between *Bursera* and *Protium* taxa. Further investigation is needed.

The final spectral comparison is that of four *Pinus* species in the present resin collection, *P. psuesostrobus*, *P. oocarpa*, *P. strobus* var. *chiapensis*, and *P. montezumae*. Fig. 45 presents these spectra in a stacked format. It is obvious that there is a great deal of variation between species in the upper region of the spectrum (Fig. 46). Only a couple of bands appear to be clearly shared: 1695, 1652 (in one, that of JHL 4779, the peak is nearly muted), 1465, 1386, and 1242 cm-1. JHL 4777 and 4779 have a common peak at 1036, which is greatly reduced in the other two samples. JHL 4761 (top) has a small, but distinctive peak at 900, and very small ones at 705 and 675 cm-1. One final point is the presence of a small, double peak in the 2400 cm-1 region: I do not know the source of this peak, or its significance in the spectra, but it is present in the first three spectra, and absent in the last. In addition, the last spectra, JHL 4779, displays an unusual degree of absorption in the 2900-1800 cm-1 region. This may be an artifact of sample preparation or a true characteristic of the sample itself. As stated previously, exudates from pines display great variation in their chemical constituents and infrared spectra.

Discussion

Appendix 2 lists exudate samples submitted to FTIR analysis and their determined identities. Each sample is accompanied by the proposed botanical origin based upon spectral comparison with the twenty six taxonomically identified resin samples in the exudate collection or botanical identification by the author. Nine of the fourteen samples are confidently assigned to a plant taxon. The Pinaceae and the Burseraceae represent nearly all of the exudate samples in the collection. One sample is designated as a balsam, probably from *Liquidambar styraciflua* or *Myroxylon* species. There are two samples with unresolved identifications and which bear some resemblance to spectra of both *Pinus* spp. and *Hymenaea courbaril*. Two samples remain unidentified at this time.

Of the nine samples now assigned to a plant taxon, four samples are represented by the family Burseraceae, a plant group with a wide distribution in the study region (southern Mexico and northwestern Guatemala), particularly in arid environments. Two of the samples are believed to be from *Bursera copallifera*, one is from *Protium copal*, and another is assigned to the family based upon what are believed to be IR bands characteristic of Mexican Burseraceae. The Pinaceae is also common in the study region and is represented in the analysis by five samples, two by *Pinus caribaea* var. *hondurensis*, one *P. oocarpa*, and one sample assigned to the family. There are approximately nine species of pine in the western highlands of Guatemala (Farjon *et al.* 1997). If people tend to utilize local exudate sources, than it is likely that other pine species present in the region are also used as resin sources, unless particular tree species are favored by the Maya, which in turn might imply a long period of cultural experimentation with many different resins and balsams.

Finding only two plant groups supplying the bulk of plant exudates sold in Maya indigenous markets was unexpected. Given the diversity of exudates to be found across the country, especially in northwestern Guatemala, and the diversity of botanical sources cited in ethnographies and historic treatments (see Appendix 1 and Table 1, Ch. IV), it was believed that other taxa would be present. There is a good deal of evidence in the ethnographic literature indicating that, at least historically, *Hymenaea courbaril* (Fabaceae, Caesalpinioideae), *Myroxylon balsamum* var. *pereirae* (Fabaceae, Papilionoideae), and *Liquidambar styraciflua* (Hamamelidaceae), were significant exudate sources in Guatemala. I was unable to document the use of these taxa as modern exudate sources. Only one sample, KT 12, bore any resemblance to *Hymenaea courbaril*, and that sample also resembled the spectrum for *Pinus caribaea* (=*P. caribaea* var. *hondurensis*). It is possible that there are *Hymenaea* exudates available in Guatemalan markets and that the sample area was too small (ten large indigenous markets spread across the central body of Guatemala). No *Myroxylon* species exudates were available as identified samples and therefore were not available for comparison to the unidentified Guatemalan samples. Only one identified sample of *Liquidambar styraciflua* was obtained, and it was reportedly collected in Guatemala. The spectra of KT 1, "estoraque", did not closely resemble the spectra of *L. styraciflua*, in spite of the historical association of the common name of the exudate with the Latin binomial. The signals produced in KT 1 indicate that it is a phenolic resin; perhaps KT 1 is derived from *Myroxylon* species. In the past, *Myroxylon* was a commonly grown exudate source in El Salvador (Standley 1946:306-308). It is still exported from that country for use as a fixative in perfumes (Adamson 1971; Coppen 1995).

Both the Burseraceae and the Pinaceae display a good deal of variation between species. The pine species available for this analysis display a good deal of heterogeneity after the 1100 cm-1 region of the spectra. Sample specimens from the Burseraceae, on the other, hand, share many peaks until the 800 cm-1 band, and peaks expressed into the uppermost region of the spectra may, under further scrutiny, be found to be roughly specific to a particular *Bursera* taxon. The limitations of infrared analysis, the reliance on comparison of only major structural groups and corresponding absorption bands, as well as the inability to determine botanical identity absolutely, are encountered in this ethnobotanical study, but do not negate the value or applications of infrared analytical techniques. In order to test the validity of FTIR identifications, a further step is required: on-site resin collection and identification of the tree source. If the FTIR data hold up in field verification, than the value of infrared techniques would be well substantiated. Future fieldwork will verify or refute these findings, but for the present, tentative identification of resin and copal sources, by analysis of infrared spectral patterns, provide evidence about natural plant resource exploitation in the southern Mexican and Central American region by the Maya.

The results of FTIR analysis of tree exudates collected, traded, and used by the indigenous peoples of Guatemala demonstrates that these natural plant products may be traced to their botanical origins. Expansion of the data set, by further collection and analysis of exudate-bearing sources, especially of those from southern Mexico, would provide the basis for studies on 1) the economic botany of resin-bearing tree species used by the Maya, and 2) comparative studies on the same order within other ethnic regions (e.g., among the Nahautl, in central Mexico). Further data on the chemistry of the New World Burseraceae, largely neglected except by Rzedowski and

Ortiz (1982; 1988) and Becerra (1997, and unpublished data), and Becerra and Venable (1999a, 1999b), would be obtained.

Chapter IV: The taxonomic identity and nature of plant exudates in the Maya cultural region of southern Mexico and northern Central America

INTRODUCTION

This chapter presents data from diverse disciplines and literatures on the primary resin-producing plant taxa exploited and used by indigenous peoples in the major Maya cultural areas of southern Mexico and northern Central America, as well as extraction and processing methods. Uses of the same resins by the international perfume industry are discussed, when possible, as indications of commercial value of resins in international trade (Adamson 1971, Coppen 1995). Chemical constituents and pharmacological data are given when available. This study intially sought to document plant resins used specifically as incense, an economically and culturally important plant product used by the Maya, but it was found that the category was too narrow in regard to the resins available commercially throughout the study area and the uses to which resins are put. Therefore, the scope was adjusted to include southern Mexican and northern Central American resins in general with copal incense as a subset category. Numerous questions are explored and addressed thoughout this chapter. For instance, which plant resins are important to the Maya and from which plant taxa are they derived? How do modern Maya use these natural products? What chemicals do resins possess that make them valuable natural products? Do the medicinal uses of specific resins used by the Maya correlate with the known chemical and medicinal properties of these resins in industrialized society? If so, how does Western medicine and commercial industry use resins? Do the medicinal uses of resins by the Maya correlate with known medicinal and phytochemical properties of resins found in international trade? What resins from the study area are present in international commerce? In spite of the widespread use and obvious importance of plant resins in indigenous American cultures, these questions have yet to be addressed by ethnobotanists.

As stated in the previous chapter, plant resins are frequently sticky, often aromatic substances composed of a complex mixture of compounds which are found throughout the organs of numerous genera, in leaves, flowers, and wood and which exude to the outside of the tree, through human activities, or as a response to other trauma. The subject of elastic latexes is also briefly addressed, because they are perceived by the Maya as tree sap, as are plant resins, and they have sometimes similiar applications. The three exudate (resins, balsams, latexes) can be variously cited in the nonchemical literature as resins, gums, juice, essential oils, or sap, indicating the inexact use of terminology and confusion regarding botanical products. These differences are addressed in the chapter on the anatomy and chemistry of resins. Cultural uses, based largely upon indigenous paradigms and beliefs, are sometimes difficult to reconcile with those of industrial, "scientific" cultures; cultural uses and applications are the focus of Chapter IV.

METHODS:

Literature from the fields of plant taxonomy, medicinal botany, and phytochemistry was searched for data on the use of natural resins by the indigenous Maya of southern Mexico and Guatemala. Valuable resources were consulted at El Centro de Investigaciones Regionales de Mesoamerica (CIRMA) in Antigua, Guatemala, the Nettie Lee Benson Latin American Collection at the University of Texas at Austin, and the General Libraries at the University of Texas at Austin.

Orthography for Maya words and cultures are described in full in the methods section of Chapter IV.

Politically speaking, all the Maya are located within Mexico, Guatemala, Belize, and small parts of Honduras and El Salvador. Mexico is considered to be part of North America. Central America is a political and geographic term applied to the countries of Guatemala, Belize, Honduras, El Salvador, Nicaragua, Costa Rica, and Panama. The term Mesoamerica is used to indicate the geographical area falling between Central Mexico and Nicaragua, and refers to the historic and archaeological period preceding the Spanish invasion and the period immediately following it. All geographic areas covered by my discussion are presented in Fig. 47 and include southern Mexico, Guatemala, Belize, El Salvador, and Honduras.

RESULTS AND DISCUSSION

The role of resins as medicines in indigenous American societies, their medicinal efficacy, and their relationship to larger scale production systems, such as the international perfume industry, is little understood. In addition, some confusion arises from the duplicate use of the term copal in Maya folk classification and in commercial industry. For instance, some of the best known types of resins in industry, "hard resins," are derived mainly from members of the Leguminosae or Fabaceae (as well as from the Araucariaceae, a coniferous group), and are commonly called copals. These resins are soluble in alcohol and nonpolar solvents, and when applied, dry as shiny, translucent, hard layers. Within the classification system of resins encountered among the Maya, however, all copals are resins very generally defined as incense (copal or *pom*) (Martínez 1959b:177) or as medicines. In my observations of the Maya, not all resins used as incense are called copal and can be given other names (e.g., *estoraque*). Identification of copal sources in the study region is problematic because the generic term is applied so widely and usually does not reflect "Western" taxonomic plant groupings (the same is true for incense in other societies as well). Approximately eleven types of incense (see Table 5.2, Ch. V), all composed of resinous exudates, were documented during my field work in Guatemala. More problematically, in Guatemala, one kind of copal in a particular area may be derived from a completely different plant source than a copal of the same name twenty kilometers away (or less), and yet share the same name (of copal or a specific kind of copal). Tremendous differences in the flora from place to place also affect any study of copal, and require taxonomic identification of numerous temperate and tropical plant species. Language and cultural differences also influence the amount and quality of collectable data. Trade and transport of resin materials remains to be documented. Resolving the different terminologies and meanings in data from industrial, chemical, and ethnographic literatures was necessary and frequently frustrating.

Following is a discussion pertaining to the subject of resins in Maya society, and of the ramifications of the material presented in the appendices. The first segment assesses the most recently published literature on plant resins and identifies the plant taxa used as sources for resins as medicines in Maya society. The second segment reviews the role of the same taxa and their exudate products in the international perfume industry. The third section briefly describes three appendices, where much data from different fields of literature are compiled and presented. The final section presents and discusses other data, primarily phytochemical, not included in the appendices.

Resins as medicines in the Maya region: the literature

All medicinal plant texts encountered, whether of Guatemalan, Mexican, or of United States publication, were examined for references to copal or the use of plant resins as medicines, but relatively few texts were found to include discussion of resin-producing taxa, despite the apparent widespread use of these substances as medicine in modern Maya culture. One exception to this trend are Martínez' *Las plantas medicinales en Mexico* (1959a) and *Plantas utiles de la flora mexicana* (1959b). Martínez includes a great deal of historic and ethnobotanical information regarding uses of numerous native taxa from the Spanish colonial period to the mid-twentieth century, as well as common names of plants and their products in the trade, geographical distribution inforrmation, and phytochemical data known up to the late 1950s. Martínez was among the first to gather data on the phytochemical components of popular and medicinally important Mexican plants, both cultivated and wild, and to present and report their uses, reputed pharmacological activities, and especially results of laboratory tests against a range of pathogens using extracts derived from the Mexican flora. Martínez (1959b:177) states that copal was the general term used by the ancient "Indians" to designate the resins produced by diverse plants (but usually from the Burseraceae) and used specifically as incense, although he discusses other uses for the same product. The above works were exemplary for the period in which they were published, and retain tremendous value in spite of recent advances in phytochemistry.

Cáceres and Samayoa's *Tamizaje de la Actividad Antibacteriana de Plantas Usadas en Guatemala* (1989) and Cáceres' *Plantas de Uso Medicinal en Guatemala*

(1996) are the most recent and most accessible works to date on the chemical and medicinal properties of the Guatemalan flora. The former treatment (Cáceres and Samayoa 1989) examines *Bursera simaruba*, which has been used as a diuretic and as treatment for diarrhea, dysentary, and intestinal infections. Studies done in Guatemala have demonstrated that a decoction of the bark induces a moderate elevation of urine in rats, while an ethanol maceration sample did not demonstrate *in vitro* inhibition of *C. albicans*, *E. coli*, or *P. aeruginosa* (Cáceres and Samayoa 1989:35). I believe that, since composition and quantity of resin constituents vary throughout the plant body, and from tree to tree, these results call for further testing of the actual exudates themselves, not tissues in which they can be located. Cáceres (1996) correlated the Guatemalan flora with available chemical data and other literature pertaining to habitat, history of use, agricultural or industrial roles, and medicinal uses. Only three resinous taxa are included the work of Cáceres and Samayoa (1989) and Cáceres (1996; *Bursera simaruba*, Burseraceae, *Liquidambar styraciflua*, Hamamelidaceae, and *Spondias purpurea*, Anacardiaceae), but the publication remains a very valuable discussion of numerous tropical plants and their potential pharmaceutical properties.

Only one other Guatemalan publication was found to include resins, *Fichas Populares sobre Plantas Medicinales* (CEMAT and Laboratorio 1992:123-126), but only in regard to *Pinus* species. Resinous wood of the pine tree, *ocote*, is mentioned as an important source of a "yellow gum (trementina)" with many medicinal uses; the needles, shoots, and wood are discussed and the turpentine distillate is addressed specifically, but not the crude oleoresin itself. *Catálogo de Árboles de Guatemala* (Aguilar 1982) completely omits any discussion of resin exudates in economically important tree species, except, again, those from *Pinus*, and possesses a great deal of confusion regarding common names and scientific nomenclature of trees known to produce exudates used as incense in Guatemala.

Only two closely related ethnographic sources were found in which discussion of plant resins went beyond a superficial level and actually identified the uses and some of the taxonomic sources of plant resins in Maya society: *The Flowering of Man: A Tzotzil Botany of Zinacantán* (Breedlove and Laughlin 1993) and *Principles of Tzetzal Plant Classification* (Berlin *et al.* 1974). Both include data on plant resins used as medicines (and as part of common ritual paraphernalia) among these Maya ethnic groups, who live in the Chiapan highlands of Mexico. More information on the *plant medica* of the Chiapas area is presented in *La Herbolaria Médica Tzetzal-Tzotzil en los Altos de Chiapas: Un Ensayo Preliminar Sobre las Cincuenta Especies Botánicas de Uso Más Frecuente* (PROCOMITH 1990) but resins are again omitted. While two species of a potentially important resin source, *Rhus terebenthifolia* and *R. schiediana*, are cited as treatments for infections of the mouth, itch or scabies, dental caries, and illnesses of the eyes, only the leaves and flowers are used, rather than exudates.

The *Flora of Guatemala* (Standley and Steyermark 1946) and *Trees and shrubs of Mexico* (Standley 1982 reprint (1920-1926)) contain good data on vernacular names, collection sites, and ethnobotanical data, for many exudate-bearing tree species. *Nomenclatura Etnobotanica Maya: Una Interpretación Taxonómica* by Barrera-Marin *et al.* (1976), is an analysis of Yukatek Maya plant classification and nomenclature, and served as an excellent reference as well. *Plants Probably Utilized by the Old Empire Maya of Petén and Adjacent Lowlands* (Lundell 1938) and *The Vegetation of Peten* (Lundell 1937) are two other valubale sources providing collection localities and ecological and economic notes on certain tropical taxa.

Export and uses of resins in international trade and the perfume industry: the literature

As indicated throughout this study, the volume of resin trade within Middle and Central America is not well known, thereby making it difficult to determine if the use of specific resin-producing species is largely local, if consumption of resins is largely domestic (on a national scale), or of an international order. If regional trade patterns and taxonomic sources (wild or cultivated) can be determined in the future, it might be possible to explore how the Maya's perceived qualities of resins affects collection, trade and consumption. It was hoped that by examining data on the international trade of resins from Central America, some light could be shed on these issues, and current "end products" be identified and traced back to their sources. This was not the case, however. Clearly, pines are critical sources of turpentine and distillation products, and statistics on volume, application, and consumption rates, are relatively easy to obtain. In contrast, it is not difficult to learn that *Myroxylon* and *Liquidambar* are considered by the perfume industry to be among the most important resin exports from the tropical Americas (Adamson 1971; Coppen 1995), but vital yield and trade data are barely forthcoming, except for a few general values. Reviews of resins in international trade, one in the early 1970s (Adamson 1971), and another in the mid-1990s (Coppen 1995), state that industry demands for consistent quality, availability, and attractive prices of raw natural materials, drives the move away from natural resins to synthetic substitutes. Still, according to the scant data that was located, certain historical and commercial trends in resin use can be perceived.

Relatively little information pertaining to resin exports from Central America and Mexico was located. The data are probably available, but they are presumably published in hard to locate, small publications. Many Latin American countries publish few copies of trade journals and these are difficult to obtain here in the United States. Developing countries which export resin supplies are likely to keep records of sources and transactions but much of the information is closely guarded or buried in government publications. In general, there is an absence of government-collected data regarding tree resins and their production and trade (within Guatemala, for example, in contrast to Nicaragua (Jan Salick, pers. comm.). One Mexican source, *Situación de la industria resinera en Mexico* (Forestales 1980) does provide information on pine species and the forest products industry of that country, but that is the exception. Information is likely to be obtained in governmental forestry departments but often require personal inquiries and visits to that country. Much of the brief discussion of commercial market values of resins and their terpenoid constituents is drawn from Adamson's *Oleoresins: production and markets with particular reference to the U.K.* (1971) and Coppen's *Gums, Resins and Latexes of Plant Origin* (1995). Very little information could obtained regarding resin exports from the Western Hemisphere. The perfume industries are, historically, secretive about their purchases of natural products, in an effort to guard perfume formulas. As Adamson warns (1971), there is little validity in speaking of individual markets for these products, and trade in resins and their compounds relies on several products derived from each species. Adulteration is a further issue; few "pure" resins are available. Prices vary greatly from decade to decade; indeed, as synthetics replace natural resins, prices have tended to drop for the natural product. Adamson hesitated to make projections for future sales of raw resins and more highly processed derivatives, citing the increase of synthetics and the retention of successful perfume formulas (Adamson 1971:8). These are important issues in the exportation and international trade of natural resins and should be kept in mind when considering their total economic value.

Although there are many indications that the decline in resin use by the perfume and pharmaceutical industries has been gradual, it is difficult to predict the economic and cultural consequences of a complete replacement of Middle and Central American sources. Although good data on exports from the region are few, is it apparent that some countries, like El Salvador, currently export most of their *Myroxylon balsamum* var. *pereirae* resin. Purchases of the balsam by United Kingdom perfume industries was as large as 50 tons per year at the end of the 1960s (Adamson 1971). *Myroxylon balsamum* is also an important source of exported balsam and a more recent report indicates that the values for the two species (*M. balsamum* var. *pereirae* and *M. balsamum*) are not separately determined (Coppen 1995:91). The potential revenue from such exports can be enormous for a small country like El Salvador; dropping export values could present a potentially serious problem for their national economy.

Description of the appendices

The paucity of information or treatments of plant resin use in indigenous ethnic societies, both in the study area and in the Americas, belies the widespread use, collection, and trade of these plant products, especially as medicines. As stated previously, much data are ethnographic in nature and scattered throughout the literature of distinct disciplines. Appendix 1 summarizes the data located in the course of this study and the appendix is subject to revision as new sources are encountered. Resins and some latexes, are considered in the appendix, largely because a few latexes have been reportedly used like resins. It has not yet been determined how the Maya perceive differences between the two kinds of exudates. Appendix 1 is arranged by plant family, genus and species, followed by a very broad description of the geographical distribution of each species, as related to the specified Maya cultural areas. The final column attempts to link these uses to ancient times, or to the modern era or both. The major plant families serving as sources of copal in the Maya cultural areas in the past and today are the Burseraceae (frankincense family), Pinaceae, Fabaceae, and Hamamelidaceae. Important latex-producing families include, but are not restricted to, the Apocynaceae, Euphorbiaceae, Moraceae, and Sapotaceae. Each of these families yields important medicinal substances and occasional domestic items. It is also notable that commercial collection of resinous materials encountered in this study was conducted on only a small scale, mostly in rural areas, and not in any apparent organized fashion. As far as I have been able to determine, none of the genera involved in resin collection, with the exception of *Pinus* and *Bursera*, is widely distributed. The genus *Pinus*, one of the most important resin sources worldwide, is planted extensively or occurs naturally in dense stands, throughout the world. Resin-bearing plants are usually found growing well away from population centers (see Alcorn (1984) for a discussion of degrees of plant domestication).

There is a category not explicitly encountered in Appendix 1 consisting of highly aromatic and/or smoky wood or bark locally referred to as *mirra*, which is defined as "myrrh" in one source (Gooch and García de Paredes 1978). The identity of the different types of *mirra* has not yet been determined but it is suspected that the bark of a species of pine is the major source. As an example, in Guatemalan markets, one can purchase a type of *mirra*, which largely consists of wood chips. *Mirra* appears to be graded according to the size of chips, from *fino* to *medio* to *regular*

(Oscar Horst, pers. comm., March 24, 1998). This particular product may be a less expensive form of aromatic smoke-producing material than plant resins, and it may have an as yet undetermined medicinal or ritual use. On one occasion, during a visit to the market at Nebaj (Department of Quiché), a vendor stated that the oak chips she was selling (*Quercus* spp.) could be substituted for copal during rituals. Oaks possess few, if any, resins (but many tannins), and although a good foundation for a hot fire, are not particularly smoky (as are most resinous woods) nor are they particularly aromatic. Whether the chips are used medicinally, and if substitution of wood chips for incense is shared throughout the country or just the region, is unknown, although one ritual offering observed in Chichicastenago (Department of Quiché), was found to be composed mostly of aromatic and smoky wood chips, and only one small *tira* or log, of copal negro.

Appendix 1 was constructed by finding and listing scientific identifications encountered in the literature, and cross-referencing those taxa with other sources. Vernacular Maya names are also included. Some major colonial Mexican sources provided some of the initial tentative identifications and discussions of plant resins; these were retained for their valuable contributions and because they they are the first scholarly treatments of European encounters with New World plants. Anderson and Dibble for instance, identified some plants in their translation of *The Florentine Codex* (Sahagún 1950-1982). In the 1943 edition of Hernández' *Historia de las Plantas de Nueva España* (Hernández 1943), many entries and descriptions given by Hernández are followed by a taxonomic identification by Mexican botanists, familiar with Hernández' works and the Mexican flora. Most of the sources (e.g., Ximénez 1967; Hernández 1943), however, do not explain the methodology of plant identifications in the texts, thus leaving room for some doubt about modern identification of colonial period resin sources. There is utility, however, in using these determinations as guides, and as a summation of current botanical understanding of resin-producing taxa. Modern floras of Mexico and Guatemala (Standley and Steyermark 1946, Standley 1982) include a great deal of ethnobotanical and linguistic data, in addition to botanical determination and locality, providing firmer corrroboration of the data as a whole. Ralph Roys' valuable, exhaustive work, *The Ethno-Botany of the Maya* (Roys 1931; Roys 1976) is occasionally cited in the present work (outside of the appendix) because it is provides a scholarly interpretation of the numerous colonial sources and the floral resources exploited by the Maya, especially for medicines.

Appendix 2 is a list of resin samples obtained by the author in Guatemala, identifying place of collection cultural use or function, cost, and description of material. Appendices 3 ("*Associated use categories of resin and latex-producing families and species from the literature*") and 4 ("*Medicinal uses of resins, balsams, and latexes in the Maya cultural region*") merely re-format the material in Appendix 1 by listing the specific uses and medicinal applications of resins and balsams used by the Maya. I discuss these applications in greater length when there is corresponding data in other literature, and unique information pertaining to a particular exudate. As can be seen in Appendix 3, the traditional medicinal role of plant resins far outweighs its other uses; incense is the second most important category. The preponderance of medicinal applications of resins in indigenous Maya cultures strongly argues for research into potential biological activity of these materials. Appendix 4 further summarizes the specific medicinal uses encountered in the literature and is restricted to modern uses, as those of the colonial period tended to be biased in favor of European perceptions of plant qualities and humoral properties. A list of terms and conditions defined for the reader is presented separately (Appendix 5). The predominant uses, according to the literature, are as vulneraries (cleansing solutions for wounds) and as remedies for skin irritations and infections. Other categories are also important, namely, applications in stomach, diarrhea and dysentary, and dental disorders. Use in respiratory illness and venereal disease follow close behind. These values, although rough and artificial, are helpful in the search for corroborative evidence of the efficacy of resins as medicines.

The major taxonomic sources of resins used by the Maya

The following section draws together diverse but pertinent data on resinous exudates from the specific families presented in Appendix 1. The following information is presented in order to give a broader context in which to view resins as medicines, as unique chemicals, and as perfumes, for which they are historically best known in the developed Western world. Part of my aim is to coordinate available data on the known medicinal properties with indigenous applications. In regard to medicinal properties of natural plant resins, it is critical to note that precise and useful data are difficult to locate and obtain. For instance, it is not difficult to locate scientific articles on the elucidation of specific compounds from *Pinus* and other coniferous species, or from *Bursera* (largely Old World species) that are often accompanied by a brief description of bioassay results of that particular compound. Such work is important, but deals with a single compound, rather than a suite of compounds, as is found in nature and in indigenous uses of plant resins the world over. No long-term studies of terpenes or phenolics in the role of health were found in the literature. The role of resins in commercial trade is also introduced, and discussed at greater length when corresponding data exists.

Each of the families included in Appendix 1 is arranged alphabetically below and the accompanying data follows a general format. Usually, I give the distribution of the relevant taxa first, then, any anatomical information on resin structures in wood and bark, followed by modern uses and chemical data when available. I diverge from this format once or twice. I refer to Old World species or data when I feel it is important or relevant to do so. Occasionally, I refer to older historical sources to illustrate long-term importance. As stated previously, the available information of plant resins is extremely patchy, and often buried throughout different disciplinary literature, hence the manner of presentation and discussion. Still, I hope to demonstrate that the medicinal uses of certain resins utilized by the Maya are supported by the "Western" data I was able to find.

I. Anacardiaceae, or cashew family

The Anacardiaceae is an intriguing, but apparently minor, source of gum-resins in southern Mexico and Central America. The geographical distribution of many species overlaps those of *Bursera* but no identifications of resinous compounds were found. In Old World species, both the Anacardiaceae and Burseraceae share many similar chemical compounds, which has led to the suggestion that the families are closely related (Khalid 1983). The morphology of both families is similar enough to make for some confusion in the field, especially with vegetative characters. It is not known to what extent the family is truly utilized in Guatemala and Mexico for its resins.

Fahn (1979:203) reports that secretory ducts in the Anacardiaceae occur in both the primary body and the secondary phloem. In *Pistacia*, a Mediterranean species, resin ducts were found only in vascular rays in certain areas of the stem (Grundwag and Werker, 1976, as cited by Fahn). Early studies cited by Fahn (1979) found the secretory structure development in *Anacardium* (again, a species not used as a resin source by the Maya, according to my research) to be schizolysigenous.

No modern references to Maya uses of the Anacardiaceae resins were found outside those given in Appendix 1. Although numerous medicinal properties have been attributed to the gum-resin exudate of the family (see Appendix 1), I could not locate any corroborative evidence in the chemical literature. In contemporary Bolivia (Rossells 1978:157), an infusion of the resin of *Schinus molle* is given for relief of pulmonary problems, ulcers, worms, and enemas, uses which match many of the those from burseraceous resins. Only indirect indications of the importance of the chemical constituents were found, and discussion of this family remains largely anecdotal. For instance, Martínez (1959b) includes a passage from Cobo (1890), in which the latter states that Inca nobility used the resin from this family to embalm and preserve their bodies after death.

II. Burseraceae or frankincense family

The primary centers of species radiation in the Burseraceae are chiefly arid regions of tropical America, north-east Africa, and Arabia. There are twenty genera and more than 600 species in the family as a whole, with the greatest diversity in tropical America (Rzedowski and Guevara-Fefer 1992:2). In the New World, the family is distributed from the arid southwest of North America, to the southeastern

United States, to the tropical forests of South America. The New World taxonomy of the Burseraceae is poorly known except for certain sections and geographical areas delineated by Rzedowski (1970, 1994), Rzedowski and Kruse (1979), Rzedowski and Guevara-Fefer (1992) and Daly (1987, 1989; 1992).[2]

The particular genera of importance in the Maya cultural area are *Bursera* and *Protium*. There are about 100 American species in *Bursera*, of which 70 are endemic to Mexico (Rzedowski and Kruse 1979; Becerra and Venable 1999a) and the resin of the genus is sometimes referred to as American elemi (Mabberley 1997). Distribution of the genus appears to be confined to the southwestern United States, Mexico, Central America, some islands in the Caribbean (Andrea Weeks, n.d.), and Brazil. The majority of *Bursera* species in Central America tend to inhabit semi-arid to arid habitats in Guatemala and Mexico, and the genus appears to achieve its greatest degree of diversity and endemism in the Río Balsas drainage in Michoacán and Guererro, Mexico (McVaugh and Rzedowski 1965:318). The resins produced by the genus are highly fragrant and harden quickly upon exposure to air. *Bursera simaruba*, while common in the moist lowlands, can also be found in drier habitats, such as that of the Motagua Valley in eastern Guatemala, and north-east central Mexico. The genus *Protium* occurs in drier habitats north of Mexico City, but it is most abundant in semi-tropical and tropical rainforests. It is probably among the chief sources of resins in the tropical lowlands of Mexico and Guatemala.

The barks of this family are diverse and often distinctive as field identification characters. The bark of certain *Bursera* species, for instance, is often thin and peeling,

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[2] The Burseraceae is the source of the Old World resins myrrh and frankincense, collected and traded within and outside Saudi Arabia, Somalia, and Ethiopia for over 2500 years (Groom 1981). Both remain significant trade items. Myrrh (*Commiphora* spp.) was traditionally used in the Old World as a medicine and frankincense (*Boswellia* spp.) as incense. These uses continue today (see Farrah, 1994, *The Milk of the Boswellia Forests: Frankincense Production Among the Pastoral Somali*).

and coppery red to green (section *Bursera*, or "cuajiotes"), while other species (section *Bullockia*, "copales"), lack this type of bark (Ramos and Engleman 1982:42; (Gomez-Vasquez and Engleman 1984:334). Section *Bursera* has corky tissues which fall away quickly and allow the sun to penetrate easily to photosynthetic tissues below, where the bulk of photosynthesis occurs (Gomez-Vasquez and Engelman 1984).

Webber (1941), in *Systematic anatomy of the woods of the "Burseraceae,"* provides a summary of studies on the family up to the 1940s. She cites Sieck's observation of schizolysigenous vertical intercellular canals in the wood of *Protium serratum* (Sieck 1895, as cited in Webber 1941), and reports her finding of radial canals in the wood of *P. copal* and *some* neotropical *Bursera* (e.g., *B. simaruba, B. graveolens*). In *Bursera microphylla*, Webber found that intercellular canals in xylem rays are continuous with those in phloem rays and suggests that this might be true for other species as well. She also found that in some specimens the radial canals of the phloem connect with vertical canals (Webber 1941:454, 456-457). These observations and others led Ramos and Engleman (1984) to test hypotheses that the presence of secretory canals in the phloem serve as an important anatomical characteristic for other members of the Burseraceae, and that these structures are nearly always present in the phloem of the root, stem, and leaves of the family (Guillaumin 1909, as cited in Ramos and Engelman 1982:42; see also Record 1921; Record and Hess 1943; Chattaway 1951; Roth 1969; Gómez-Vasquez 1977). They report that axial, tangential, and radial resin canals occur in the bark of Mexican *Bursera copallifera* and *B. grandifolia*, forming a network in the functional and nonfunctional phloem via anastomosis. They also found that in both species the axial canals in the primary plant body form schizogenously[3]. In *B. copallifera* the radial canals of the xylem connect

[3] Although not closely related and an Old Word species, *Commiphora wightii* is reported by Bhatt (1987) to possess schizogenously derived resin ducts.

with those of the phloem through the cambium (Ramos and Engelman 1982). Gómez-Vazquez and Engleman confirm that similar types of resin structures are found in *B. longipes* (Gómez-Vazquez and Engleman 1984).

An examination of label data on herbarium specimens at various institutions (MO, LL, NY, GH (Economic Botany Division) testifies to extensive use of the Burseraceae as a source for copals as medicines and incense. These data sources are important because of the ethnobotanical data sometimes recorded on them. Sometimes the only known cultural use of certain plants come from specimen labels. Thus, von Reis Altschul (1973:136-138) studied herbarium labels at the Gray Herbarium (Harvard University Herbaria) and noted that resins from *Bursera fagaroides* and *B. penicillata* resin were recorded as remedies for toothache (Gentry 2260, 1936; *Gentry 1585*, 1935); *B. grandifolia* for fevers (*Gentry 2260*, 1939); and the powdered resin of *B. simaruba* was used for stomachache (*Standley 19636*, 1921-1922); *B. trifoliata* is recorded by Hinton (*Hinton 7781*, 1935) as poisonous. Other specimens, examined by von Reis Altschul and Lipp (1982), at the New York Botanical Garden provided data on yet other species: *Bursera* spp. was used as incense (*Hinton 10851*, 1937), and *B. simaruba* was "used as tea and incense" (*Hill 2346*, 1974), teas "drunk as remedy for backache" (*Degener 19011*, 1946), and the leaves of the tree even used to feed livestock (*Cerbin C 150*, 1973) (von Reis and Lipp 1982:147-146). My examination of herbarium specimens, in the Economic Botany Division of the Harvard University Herbaria, yielded just a few more ethnobotanical uses: *Bursera fragilis* (*Palmer s.n.*, 1885), was annotated by Robert Bye, a specialist in ethnobotany and the Tarahumara of Chihuahua, Mexico, and included the information that "'Torote" exudate [is] used by the Tarahumara for chewing gum when hardened and in form of plaster as an application to aching joints; also rubbed on their fiddle bows" (Bye, 1975). A similar use is recorded for *B. stenophylla* (*Palmer 200*, 1885; *Bye s.n.*).

Infrared analysis of resins collected in northwestern Guatemala indicate that *Bursera copallifera* and other species is a likely source for some exudates used as incense, as is *Protium copal*, from Guatemala.

I would like to refer to the colonial Spanish period for a moment, in which numerous dictionaries, reports (*relaciones*), and native medical texts were written[4] The resins most predominant in the *materia medica* of the colonial Yucatán Maya were from the Burseraceae (the use of the Euphorbiaceae latexes exceeded this family, however). *Bursera graveolens*, and *B. simaruba*, as well as *Protium copal* (Roys 1976: 277-278) were employed in the treatments of respiratory problems, snakebites, diarrhea and dysentary, abdominal pains, fever, biliousness, ulcers, gum problems, and so forth. Many of these perceived properties are still shared by modern Maya elsewhere in Central America, as Appendix 1 demonstrates. Curiously, a disease was named, after a fashion, for copal, according to Roys. *Pom* is the Maya word for incense and for the exudate from which it is made, and is a term much more common in eastern Guatemala than it is in the west. The disease is *pom-kak*, the Maya name for smallpox, meaning "copal-burns." The pustules resemble the burns on the hands of those making offerings of copal incense, the resin of *Protium copal* (Roys 1976:168). Roys tells us that Maya doctors believed in curing like with like (Roys 1976:xxi). Roys cites a provocative statement from the *Chilam Balam of Chumayel*, that the gum, from *Protium copal*, is "called the center of heaven...and the brains of heaven"

[4] For example, Roys' *Maya Ethno-Botany* (1976), compiles numerous colonial texts, among them the *Motul Dictionary*, a 16th-century manuscript, Landa's *Relación de las Cosas de Yucatán*, Ossado's *Yerbas y Hechicerias del Yucatán*, *The Books of Chilam Balam*, books of incantations and ritual, of which there are several, and *The Ritual of the Bacabs*, and many others.

(Roys 1976:278). This provocative statement is examined in greater detail in Chapter IV.

Commercial and domestic use and trade of the Burseraceae in Mexico appears to have been significant in the recent past. Martínez (1959:367-371) relates that three varieties of resins from *Bursera aloexylon*, or linaloe, are recognized: 'linaloé fino,' 'linaloé corriente,' and 'linaloé comino,' the latter of which is redolent of cumin. These types are distinguished by the appearance of the tree and the odor of the essential oils and may be associated with more than one fragrant-smelling species (McVaugh and Rzedowski 1965:339), although it is said that some species (e.g., *Bursera microphylla*) smell like gasoline (possibly because of a high content of styrene). Exportation of linaloe in 1945 was approximately 39,810 kilograms but fell to a minimum of 9,497 kilograms in 1947. Levels of export were increasing in the late 1950s (Martínez 1959:367-371). Rzedowski and Guevara-Féfer (1992) relate that the essential oil is still in use by the cosmetic industry, as does Funamo (1981, as cited in (Schultes and Raffauf 1990:116), but no further data on burseraceous resin production or exports were located. On the other hand, *B. aloexylon* is considered by Lewis and Elvin-Lewis (1977:83) to be irritating to the skin; linalool, a monoterpene contained in the essential oil, causes contact dermatitis in some individuals. The reputed use of *B. aloexylon* in the cosmetics industry, however, poses an interesting challenge to this report, as well as to its use by cosmetic consumers. Martínez also provides us with one of the few available descriptions of different methods of resin collection, and tells us that the trees must be at least fifteen years of age, but preferably twenty to thirty years (Martínez 1959:368). According to Martínez (1959b:178), the resins of *B. microphylla* are collected in the months of September and October, and generally collected with maguey leaves. In the domestic markets of Mexico, *Bursera* resins come in a range of colors and forms, and are organized and priced according to grades and aromatic qualities. For example, a recent purchase of four samples of copal in a Mexico City market, confidently identified as being from the Río Balsas drainage in Michoacán (Mexico) by Dr. Robert Bye (pers. comm., 1998) and likely to be derived from *Bursera* species, display a great range of form, size, and color: from a pure white flow of aromatic resin, about four to five inches long, to a mix of small, gritty grains, yellowish white to russet brown. Other colors and grain size classes undoubtedly exist and will come to light with further research in that particular geographical region.

The exudates of the Burseraceae contain a high volume of volatile mono- and sesquiterpenes, with triterpenoid constituents. Carbohydrates are often present as well. Triterpenoid resin acids, and triterpene alcohols, such as α-amyrin, and burseran (Lewis and Elvin-Lewis 1977:135) are found in Old World Burseraceae, but no corresponding reports of terpene compounds in Central American Burseraceae have been found. The chemical variations between, and evolutionary relationships of, a few Central Mexican *Bursera* species have been investigated by Rzedowski and Ortiz (1982, 1988), Becerra (1997), and Becerra and Venable (1999a and b), but in Rzedowski and Ortiz' work (1982, 1988), the chemical consituents were not formally identified and published, only the retention times and relative proportions of each. Judith X. Becerra (pers. comm.) has identified the terpenes of *Bursera schlechtendalii*. They are (in order of importance): beta-phelandrene, limonene, beta-myrcene, sabinene, alpha-pinene, and nonane. Dominguez *et al.* (1973) published a study of the chemical constituents of twenty one species of Mexican *Bursera* but the paper has not been available through library services. To the best of my knowledge, no other systematic chemical studies have been conducted or published on the New World members of the Burseraceae. Isolated studies demonstrate that some medical benefits have been attributed to specific North American burseraceous compounds, mostly non-terpenoid. For instance, Bianchi *et al.* (Bianchi *et al.* 1968; Bianchi *et al.* 1969) screened plants of the Southwestern United States for potential antitumor activity and found that the chloroform extract of *Bursera fagaroides* demonstrated significant activity, as did two lignans (non-terpenoids) found in *B. schlectandalii* in a different study (McDoniel and Cole 1972; Lewis and Elvin-Lewis 1977:135). An examination of antitumor activity in *B. microphylla* (Bianchi *et al.* 1968:696-697) has shown deoxypodophyllotoxin (another lignan–non-terpenoid) to be an active compound. While these last studies did not specify the origin of the material analysed, they confirm that nonterpene compounds in the genus are potentially useful pharmaceuticals.

Moore (1989:51) reports that the general chemical constituents in the tinctures of the bark, resin, and leaves of *Bursera microphylla* have immunologic stimulation similar to myrrh, increase phagocytosis, the number and quality of serum white blood cells (PMNs), as well as granular streaming. The tincture can help to relieve sensations of feeling run down and strengthen resistance to stress, and decreased immunity. According to Moore (1989:51),

> the aromatic oleoresins are primarily excreted in the urine and mucus as intact waste products; as such they inhibit bacteria and other microbes, stimulate the scavenging of white blood cells in those tissues, and increase the softening and expectoration of bronchial mucus. [*B. microphylla*] would be classed, therefore, as an excretory disinfectant, mucolytic, and immunostimulant. As it, like myrrh, is strongly astringent as well, the various preparations are very useful in treating gum and mouth inflammations....[Contraindications are]

kidney disease (may induce inflammation), pregnancy (may overstimulate uterine blood supply), and necessary immunosuppresant therapy.

I was unable to locate any other data with which to compare Moore's statement.

I would like to diverge from New World Burseraceae for a moment, and look at a mostly Old World genus of the family, *Commiphora* (myrrh), in order to consider the potential medicinal properties of Central American resins[5] because there is indirect evidence that anodyne properties may be present in *Bursera* and/or *Protium*, in the future. Used medicinally by the Egyptians to the twentieth century, myrrh was employed as an embalming agent, anointing oil, for infections, respiratory problems, and as a vermifuge. A study of the analgesic effects of myrhh (*Commiphora molmol*) by Dolara *et al.* (1996) may have some interesting parallels to the chemistry of New World Burseraceae. Dolara *et al.* tested the pain response of mice placed upon a metal plate at a temperature of 52° C, after administration of a ground myrrh-saline solution. The latency of pain reaction was significant ($P<0.01$) (the period of time before licking occurs is a measurement of the efficacy of the compound as a pain reducer). Three sesquiterpenes were identified using silica-gel column chromatography, high-pressure liquid chromatography, nuclear magnetic resonance, and mass spectrometry. The compounds, furanoeudesma-1,3-diene, curarene, and furanodiene, had been previously identified but their biological properties had not yet been described. It was found that the most plentiful compounds, furanoeudesma-1,3,-diene, and curzarene, increased licking latency, but that furanodiene did not. The first compound also reduced the number of abdominal muscle contractions after

[5] *Commiphora tecomaca* has recently replaced the Mexican *Bursera tecomaca* ((DC.) Rzedowski and Palacio-Chávez).

administration of an acetic acid solution, and was reversible with naloxone. Following characterization of the binding of furanoeudesma-1,3-diene to opiod receptors in brain cell membrane, the authors concluded that the analgesic effects of the compound, blocked by nalaxone, indicate an interaction of the active compounds with brain opioid mechanisms. They suggest that the biological activity of *Commiphora molmol* may help to explain the widespread use of myrrh in the past, and assert that replacement of myrrh by opioid derivatives at some later period may have occurred. There are also, however, according to the authors, other compounds present whose identity is unknown or with unfavorable pharmacological activity (Dolara *et* al. 1996:29). Another set of researchers investigated the analgesic effects of *Boswellia serrata* (Burseraceae) (Kar and Menon 1969:1023-1028). Very recently, a new health food product was released, a lotion to relieve arthritic pain, Boswellin®, whose active ingredients are derived, in fact, from *B. serrata*. I cannot confidently ascribe similar properties to the major Burseraceae resin sources considered in this paper, especially as so few have been identified and isolated, but I believe that compounds with promising medicinal properties remain to be discovered.

III. Fabaceae or legume family

The genera *Hymenaea* and *Myroxylon* are among the most important resin and balsam sources in the Fabaceae, or legume family, in Central America. The former genus produces terpene resins, while the latter produces phenolic resins.

Hymenaea courbaril, or guapinol

Hymenaea courbaril is a member of the subfamily Caesalpinioideae (tribe Detarieae), and is widely distributed throughout Central and South America, and occupies a wide range of habitats (Langenheim and Lee 1974:3, Fig. 1). The resin produced by *Hymenaea* hardens rapidly and in indigenous uses finds application as medicines and rituals, as well as in domestic functions. The species occupies a wide range of habitats and is known to produce enormous masses of resin that may later accumulate in soil (Langenheim 1969, 1990). Although some herbarium collections of *Hymenaea* observed at the Harvard University Herbaria (GH, Economic Botany Division), were from the Alta Verapaz region (e.g., *Standley 92677* (1941, alt. 1300m), *Tuerckheim 7842* (1901, alt. 350m), this tree species was not observed during my 1995 field work season. It is possible that extensive land clearing in the region has greatly reduced populations of *Hymenaea* or that I did not possess the recognition skills to detect it. The fruit of *Hymenaea* is distinctive and laden with resin pockets. One vendor in Cobán (Department of Alta Verapaz) was found selling the fruit in one of the markets, and when asked what the fruit was used for, she stated that when young, the soft part around the seeds was eaten, and when the fruit became hard (after maturation), it could be boiled with water to retrieve the fragrant oils within (the fruit pod is dense with secretory structures). The fruit itself was expensive and was seen in the market only the one time (late February-early March). In her work on the determination of botanical sources of amber from different parts of the world using infrared analysis, Jean Langenheim found evidence that amber mined in Chiapas, Mexico, was fossilized resin from a relative of *Hymenaea courbaril* and *H. intermedia* (Langenheim and Beck 1965, Langenheim 1969, 1990, 1995), indicating the long-term presence of the genus in Mexico and Central America.

Langenheim and others have conducted research on the ecological chemistry and some anatomical work in the genus *Hymenaea*, with emphasis on qualitative and quantitive resin composition in leaves (e.g., Langenheim 1981; Langenheim *et al.* 1982). Wood resin of *Hymenaea* is largely produced schizolysigenously, exuding from long vertical fissures in the bark, with a great deal of resin stored internally near the cambial zone. Resin synthesis occurs at the site of wounding or tapping (constitutive and induced resin production; Langenheim 1969:1166, 1995, Fig. 5) as well. Polymerization of labdatriene diterpenoids in the resin occurs shortly after exudation from the tree, especially in the presence of sunlight, to produce a tough substance (Langenheim 1995:12-13).

Terpene resins occur only within the tribe Detarieae, although phenolic resins (balsams) are found in other tribes of the family (i.e., *Myroxylon*) (Langenheim 1981, 1995). Resins from the tribe are commonly known in industry as copals, or "hard resins" (Langenheim 1981:632). Excellent varnishes are made from the resins, due to their rapid drying properties, translucence, and durability.

Myroxylon balsamum var. *pereirae, or balsam of Peru*

The genus *Myroxylon*, a member of the subfamily Papilionoideae, is also an important leguminous source with a high essential oil content. The exudate is technically a balsam, in that it consists of terpenes suspended in phenolic acids. The resin product is known as "balsam of Peru." It is described as a "dark brown, very viscous liquid, with a 'balsamic' odour, somewhat resembling vanilla" (Coppen 1995:91), or cinnamon. I believe that *Myroxylon* remains an important source of resins in Guatemala but I have not yet observed the genus in the field. The resin has been described as fragrant, thick, deep brown or black liquid, and was reportedly introduced to Sri Lanka from El Salvador (Smith *et al.* 1992). ***Myroxylon*** **has been important historically as a source of medicine, and especially as an export product** (Feldman 1985:80; **Martínez 1959a:46-49; Ximénez 1967:244). I have seen only a** few relevant herbarium specimens of ***Myroxylon balsamum*** for ethnobotanical data and locality. C. L. Lundell made a collection of *M. balsamum* (*Lundell 6338*, 1936, GH) in the El Cayo District of Belize, as did M. Balick (*Balick et al. 1804* (1980s or 1990s, GH). Data on *Myroxylon* was not located in von Reis and Lipp (1982) or von Reis Altschul (1973). It is also likely that it grows in intact tropical forests in El Salvador, especially along a section of Pacific coast called "Costa del Balsámo," located southwest of Acajutla, in the Department of Sonsonate.

Morton (1977:166) reports that crude "Peru balsam" consists of 25 to 30% resinous material and 65 to 65% essential oil. More recent accounts state that *Myroxylon balsamum* var. *pereirae* contains about 80% resin derived from resin alcohols combined with cinnamic and benzoic acids, and is rich in free aromatic acids (about 12-15% free cinnamic and about 8% free benzoic acids). Other consituents are esters, such as benzyl benzoate, benzyl cinnamate (cinnamein), and vanillin. The presence of other esters, peruresinotannol, cinnamate, styrene, eugenol, ferulic acid, 1,2-diphenylethane, and some mono- and sesquiterpenes hydrocarbons and alcohols, has been demonstrated. Numerous triterpenoids are also present. 35 to 50% of total balsamic acids have been calculated on the dry alcohol-soluble matter (Tyler *et al.* 1976:193; Evans 1996:183).

In contrast to the widespread method of extraction by creating an incision in the bark (explained more fully below), Ximénez (1967:244) states that resin of this tree was extracted with fire, literally "sácanlo con fuego, mojando paños en lo que suda." García Palacio (1985) described a similar method over a century later. One source (Hale 1911) states that after the trunk is heated by fire the inner bark of the trunk yields resin. Others complain that sometimes this extraction technique produces a smoky odor in the balsam (Wells and Billot 1981:114). Each year the method is applied, about a meter above the previous patch (Smith *et al.* 1992:254). Cloth is applied to the bark to soak up exudates, and is then boiled to extract compounds. This is known as the *panal* (cloth) or *trapp* (rag) collecting process (Duke 1981:177). Monardes (1925:23) states that the natives would cut boughs and large pieces of wood into small chips and boil them in water and cooled, and the oily residue skimed off, which was then stored. Martínez (1959:68) describes a similar process for Mexican members of this species. Harvest is in November and December, and he adds that one tree produces one to two kilos per year. Adamson (1971) states that the average annual production of balsam of Peru in El Salvador was approximately 150, 000 pounds, of which half was exported to the United States, though he provides no citations.

In the industrialized world, resin from *Myroxylon balsamum* var. *pereirae* has been and continues to be used as a mild antiseptic in topical preparations for treatment of eczema and pruritus. It is also an ingredient in some preparations for the relief of hemorrhoids and respiratory congestion (Reynolds 1996:1740-2). According to Duke (1981:175), balsam of Peru has been used extensively as a local protectant, rubefacient, parasiticide in certain skin diseases, antiseptic and vulnerary, is applied externally as an ointment, or in alcoholic solutions; and internally, rarely used as an expectorant. The dried fruits of *Myroxylon balsamum var. pereirae* are offered in Guatemalan markets to reduce itching. The presence of phenolic compounds such as benzyl benzoate and benzyl cinnamate may provide a mild antiseptic action to the balsam (Coppen 1995:91, 92). The Agricultural Research Service's Phytochemical and Ethnobotanical Databases (World Wide Web) relate that benzyl benzoate has been reported as antiallergenic, antiasthmatic, antispasmodic, as a central nervous system stimulant, and as an insectifuge, among other uses (Duke 1998).

Roys (1933, 1976) describes the prehispanic and early colonial uses of *Myroxylon balsamum* var. *pereirae* in the Yucatán. Applications were medicinal and differ from uses reported from later periods in other parts of Mexico and Guatemala. For instance, as in traditional European practices in the fifteenth and sixteenth centuries, it was the habit of the Maya to smoke the patient's entire body with incense in conjunction with "cupping," to rid the body of abscesses and skin eruptions and to warm the body (I do not know if cupping existed as a Maya treatment prior to the arrival of the Spanish). Copal incense (*Protium* spp.) was used in this capacity (Roys 1976:81-82). Balsam of Peru was also used to cure "protruding hemorrhoids." The primary treatment recommends making a suppository of sorts, with soft lint and resin, or to smoke the rectum with the same resin (Roys 1976:167). It is unclear how prevalent the species was in the region during the period in which the texts were composed, and the genus *Protium* appears to be much more important in the Yukatek Maya's *materia medica* than *Myroxylon*. In accordance with the uses of *Myroxylon* elsewhere, however, the primary property of the balsam was to reduce swelling. In colonial highland Guatemala balsam of Peru was used for colds, respiratory illnesses, and healing cuts and old wounds. The same resin is reportedly used for scabies or other skin parasites in the same region (Orellana 1987:114, 120, 122, 219-221).

Adamson (1971) states that nearly all commercial exports of the resin of this species originate in El Salvador and that it is used in its natural, unadulterated form in perfumery as a fixative, but the oil (or resin-free derivatives) is preferred because of the dark color of the crude material; insolubility of some of the components is also problematic. Wells *et al.* (1981) contradict this statement by noting that the components of "*Myroxylon pereira*" [sic] blend well with floral, powdery, and woody perfumes, oriental, and spicy notes, and are held in high regard as fixatives and that the balsams are purified, made into alcoholic extracts, co-distillates, resinoids, and and a range of oils for perfumery. They also note that both *M.balsamum* var. *pereirae* and *Myroxylon balsamum* are sometimes adulterated with copaïba (*Copaifera* spp., Fabaceae, a South American genus which does not occur in Mexico or northern Central America but is present in southern Costa Rica and Panama), colophony (distilled *Pinus* spp. resin), and other similar substances (Wells *et al.* 1981:114). Some of the other common constituents, such as vanillin and farnesol, may also have medicinal qualites (Duke 1998). Raw resin is rarely sold for perfumery purposes; dilution to a liquid form is offered commercially. Purchases of the resin by United Kingdom perfume industries was as large as 50 tons per year at the end of the 1960s (Adamson 1971) and more recent data indicate that the values for the two balsams (*M. balsamum* var. *pereirae* and *M. balsamum*) are not separately determined (Coppen 1995:91).

Myroxylon balsamum var. *balsamum*, or balsam of Tolu

Few data were located on this species in particular, at least for southern Mexico and Central America, in contrast to *M. balsamum* var. *pereirae*. The exudate is not synthesized by the tree until it has been injured, and is, therefore, of pathological (or induced) origin (Evans 1996:259). Apparently once a product used by the Inca, indigenous Columbians continue to use the balsam to treat wounds and to stop bleeding, even in "orthodox medicine," especially when bleeding is profuse. There is little residual scarring left on the skin (Lewis and Elvin-Lewis 1977:342), suggesting that the resin may help in the reduction of scar tissue and healing. Much of the balsam product from this species and the preceeding are imported to an unspecified buyer and then sold again, to other countries (Table 25, in Coppen 1995:92). The average yield of a balsam of Tolu tree was as low as 1.7kg/tree per year (Williams 1974, as cited in Coppen 1995:93). The usual method of extraction is apparently by incision (Coppen 1995:93). The balsam is exported from El Salvador and Belize in tin canisters (Evans 1996:183).

The essential oil content of the resin of this species is reportedly low and cleaned products are more common in perfumes and pharmaceuticals than the balsam itself (Adamson 1971:15). Coppen describes the resin as a "brownish yellow, plastic solid when fresh, but becomes harder, and eventually brittle, upon exposure to air" (Coppen 1995:91). Adulteration of the product seems fairly common as well. Nearly all of the commercial supplies originate in the Tolu province of Colombia. Arctander (as cited in Adamson 1971:15, no bibliographic data given) estimated that the annual world production of Tolu balsam to be approximately 100 tons, and that the United States imported one third of this total. The essential oil is used as a fixative for cooking flavorings, and the resinoid and absolutes (extracted with hot alcohol) in perfume fixatives. A great range of qualities and names for these products exists in the markets (Adamson 1971:15).

Official drugs utilizing *Myroxylon balsamum* var. *balsamum* are required to possess no less than 45% and no more than 70% resin esters (e.g., toluresinotannol), demonstrating a wide range of values for this constituent. The primary balsamic esters present are benzyl cinnamate (cinnamein), benzyl benzoate, and cinnamyl cinnamate (styaracin). About 28% resin is also present, said to consist of triterpenoids (e.g., oleanolic acid, sumaresinolic acid), peruresinotannol combined with cinnamic and benzoic acids, resin alcohols (nerolidol, farnesol, and benzyl alcohol) and small quantities of vanillin and free cinnamic acid (Tyler *et al* 1981:161; Evans 1996:183-184; Wren 1998:268). The balsam is still used extensively in pharmaceutics as a feeble expectorant and catarrh inhalants, although Coppen states that many "Tolu syrups" have been replaced with synthetic mixtures (Coppen 1995:91). Wells *et al.* (1981:115) state that the main constituents of *Myroxylon balsamum* var. *balsammum* are identical to those of *M. balsamum* var. *pereirae*, but with greater quantities of benzoates and cinnamates, plus guiacol, creosol, and phellandrenes.

Pterocarpus officinalis

Although no chemical data on this leguminous species were located, Lewis and Elvin-Lewis (1977:254) have found evidence that gums or resins (the exudate) of related species, are used in India for relief of toothache pain.

IV. Hamamelidaceae (=Altingiaceae), or witch-hazel family

Liquidambar styraciflua or storax, is distributed through the southeastern United States to the high elevation, temperate vegetation in humid mountains of Guatemala. *L. styraciflua* produces phenolic resins, and the main constituents are said to resemble those of the Asian species, *L. orientalis* (Tyler 1976:193; Evans 1996:184). Morton reports that the purified balsam contains 30 to 50% storesin (an alcoholic resin). Phenolic composition consists of 5-15% free cinnamic acid, 5-10% cinnamyl cinnamate (styracin), about 10% phenylpropyl cinnamate and small amounts of ethyl cinnamate, benzyl cinnamate, and phenylethylene (styrene) (Morton 1977:129-130; Wren 1998:260). An aromatic liquid, styrocamphene, is found with traces of vanillin (Morton 1977:130). There are reports of the presence of some terpene alcohols, which may have medicinal properties (Wells *et al.* 1981:114; Duke 1998).

While virtually no other additional data were located regarding indigenous uses of *Liquidambar* by the Maya (other than that in Appendix 1), Vogel (1970) devotes considerable attention to this American species. It was extremely popular among the native North Americans and early settlers. Numerous explorers document indigenous uses, and applications were much the same as for their Central American counterparts, with the medicinal virtues considered comparable to those of balsam of Peru (Catesby 1754, Bossu 1751-1762, Le Page du Pratz 1758, as cited in Vogel 1970:379). *Liquidambar* was even called "copal" or "copalm" by the early French and Spanish visitors to North America. Vogel (1970) also reports that the balsam of the trunk of *L. styraciflua* was listed in the U. S. Pharmacopeia in 1926, under the name American Storax, and that it is still official (no evidence was found that *L. styraciflua* is retained in the U. S. P.). It is used as a stimulant, expectorant, and for antiseptic purposes (Vogel 1970:37-379). Early settlers in the United States are said to have used the resin to alleviate pain and inflammation of cold sores, recurrent herpes, and fever blisters (Lewis and Elvin-Lewis 1977:263).

Liquidambar styraciflua is used in perfumes and soaps with lilac, hyacinth, and other floral notes (Adamson 1971:10-11; Wells *et al.* 1981:114). Distilled oils and extracted resinoids (extracted with benzene) are more valuable than the crude resin itself (Coppen 1995:89), and adulteration of the oil is apparently common. Wells *et al.* (1981:114) state that storax is produced in Honduras and also yields resinoids. Liquidambar balsam is still used pharmaceutically in traditional bronchial medicines, but as synthetic substitutes and antibiotics become increasingly available in developed countries, the primary markets are developing countries. Supplies in the late 1960s and 1970s were predominantly from Honduras and Guatemala, and were purchased in a crude, uncleaned form by the United States, reportedly the largest buyer of storax. This trend continues but no trustworthy exportation data were found by Coppen (1995) in his recent review of resins, latexes, and gums in international trade. He found that the United States continues to import the greatest quantities of American styrax but no yield data could be located, while older sources indicated an average annual yield of around 20 kilograms of balsam per tree in Honduras, where the tree is tapped.

V. Pinaceae or pine family

Pines are widely distributed globally, and are found in humid temperate to subarctic climates and well drained soils, and in tropical climates at higher, cooler altitudes, or on well drained ridges, low-altitude ridges. In the western hemisphere, pines are distributed throughout much of North America to Nicaragua and are the most important resin-producing taxa in relation to other members of the family in terms of resin production. In such countries as Mexico and Guatemala, pines tend to be found in interior, mountainous areas, such as Michoacán, Chiapas, and Morelos. These regions are cool to cold and receive ample moisture. In Central America the genus is highly diverse and contains at least fifty species (Perry 1991; Farjon *et al.* 1997).

Based upon the reported botanical sources in the resin source plant list (Appendix 1), it is likely that the most important colonial and post-colonial sources of pine resins were from such mountainous areas as Michoacán, Morelos, and Chiapas, Mexico, and the western highlands of Guatemala (although little information was found regarding historical uses of pines in the latter). While most species are distinctive and easily identifiable in the field, a great deal of hybridization occurs, especially in the highlands of Mexico (Perry 1991).

Infrared analysis of resin exudates from Gautemala indicates that many resins purchased in the western highland markets are derived from *Pinus* spp., most likely *P. oocarpa* and *P. caribaea* var. *chiapensis*.

In the Pinaceae, interconnected radial and vertical ducts are found in the wood, while only radial ducts exist in the phloem, ending in an enlarged cyst-like vesicle. Phloem ducts form schizogenously (Fahn 1979:191-194). The family in general is well studied in terms of phylogeny, morphology, and plant-herbivore relationships, and a large body of literature exists on the structure and development of secretory tissues in the family as a whole (e.g., (Werker and Fahn 1969; Fahn and Zamski 1970; Fahn and Benayoun 1976; Fahn 1979); and much descriptive anatomy exists from ca. 1907 to 1936.

Mono-, sesqui-, and diterpenes (mostly acids), and some phenolic compounds, are present in the oleo-resin (small quantities of triterpenes are occasionally found in the genus *Pinus*, according to San Feliciano and López (1991:2). Principal monoterpene components of pine resins are α-pinene, β-pinene, limonene, myrcene, β-phellandrene, and 3-carene (Gershenzon and Croteau 1991:176). Sesquiterpenes include cineole and β-bisbolol. The most common diterpene acid compounds found in *Pinus* are of the labdane, abietane, and pimarane skeletal series. One of the most common diterpene acids is abietic acid.

Pines are perhaps best known for their use as turpentine and rosin. In southern Mexico and Central America pine resins appear to have a wide range of uses as medicines and as incense, and are most commonly found in markets within, or close to, highland market regions. In only one instance (Chiquimula, Guatemala) were incense products possibly derived from pines found in lowland markets of Guatemala or Honduras, although Scholes and Roys (1968:58) report trade of pine resins as incense in colonial Yucatán. Turpentine, a distillation of pine resin, is an oleoresin recommended as a relief for muscular pain and rheumatic arthritis in modern Guatemala (CEMAT and Laboratorio 1992:123-126). According to Reynolds (Reynolds 1996:1764-1) and Wren (1998:271), however, turpentine is no longer thought to be safe or effective, and death may result from administration of the product.

VI. Styracaceae or benzoin family

Styrax argenteus is native to the Americas. Most data concerning the use of resin from this tree are anecdotal, except for use by the Tzotzil Maya of Chiapas. Gathering from the synonomy of the term 'estoraque,' for this plant, and the same term for *Liquidambar styraciflua* (Hamammelidaceae) in Guatemala, it is possible that these trees share similar morphological features in Maya plant classification systems. But these features are dissimilar, according to Western plant classification principles: *Liquidambar styraciflua* has gray-brown, furrowed bark, with aromatic, deeply lobed, star-like leaves, with numerous pigments, while *Styrax argenteus* has often smooth, obovate leaves, and is placed in a different taxonomic order altogether (Cronquist 1981:173, 501). The term for one particular kind of resin product, purchased in a highland Guatemalan market (Momostenango), is *estoraque*. I have not yet been able to identify the source, but I suspect it may be from *Liquidambar* or *Myroxylon*.

VII. Zygophyllaceae or lignum-vitae family

The wood and bark of *Guaiacum coulteri* and *Guaiacum sanctum* (lignum-vitae) yields resins which were once considered to be the most effective treatment for syphilis by the Spanish and much of Europe throughout the colonial period. The only native text in which *Guaiacum* was identified as a resin source is from Roys (1976: 311-312). *Guaiacum* is part of the Yucatán flora, and Roys provides several confirmations of its medicinal importance, especially in the cure of "buboes," a Spanish term for syphilitic sores.

Monardes, a sixteenth-century Spanish physican, provides the only description of extraction methods and applications I was able to locate. Twelve ounces of the wood, and two ounces of wood chips ("rinde") are steeped in water for twenty four hours, simmered and reduced by two thirds. Cooled and strained, the residual water was then bottled. A second boiling and reduction was made of the wood and stored separately. The stronger infusion was drunk to induce perspiration, and later, after eating and drinking water, the second solution was drunk. This procedure was alternated for some weeks. Monardes claimed that the lengthy treatment period he describes (about forty days) cured a man of syphilis, and served as protection against further infection. Oviedo also reported the same information to King Charles V in 1526 (Oviedo 1959 [1526]:88-89). On the other hand, in modern sources the resins of *G. officinale* and *G. sanctum* are reported to cause nausea (Lewis and Elvin-Lewis 1977:279).

Evans reports that some of the main resinous consituents of *Guaiacum* are lignans (phenolic compounds). The flowers, fruit, and bark of the tree have triterpenoid and nortriterpenoid saponins (Evans 1996:291). Resin acids (e.g., (-)-guaiaretic, guaiacic) and terpenes (e.g., guaiagutin) and phenolics (e.g., vanillin) are cited by Wren (1998:136). *Guaiacum sanctum* and *G. officinalis* were listed at various times in the U. S. Pharmacopeia, and it is permitted as a food additive in the United States and Europe. It is also included in the *British Herbal Pharmacopeia* as a treatment for chronic rheumatic conditions (1990, Vol. I, as cited in Evans 1996:291). Vogel (1970:410) classifies the wood chips and resin from the wood as diagnostic agents, with stimulant and diaphoretic properties, and mentions that they have also been used in veterinary medicine as internal antiseptics (in spite of their potential to cause nausea in humans).

The genera and species discussed above are among the most significant sources of plant resin exudates, used by historical and/or modern Maya. As stated previously, many plants contain terpene and/or phenolic compounds and many times substances given in the literature are described as resins, simply because they are an exudate, when they may not be, as in the case of latexes and gums. In other cases, the wood may contain resin compounds but not necessarily exude them. As one can see, the sources of resins and balsams used by the Maya are numerous and of a general nature but usually falling within several distinct categories. Copals, in the traditonal Maya definition, do not always correspond with modern, industrial definitions and sources, as in the case of the Fabaceae, which is designated by industry as the primary source of "hard" copals.

Taxonomic sources of latex in the Maya cultural region of southern Mexico and Central America

Elastic latexes hold an important position as exudates in ancient and modern Central America as demonstrated in Appendix 1. Many of these elastic latexes are commonly referred to as rubber, a general term applied to more than one plant source.

The Euphorbiaceae (spurge or poinsettia family) is probably best known as the most important modern source of elastic rubber and is obtained from the South American *Hevea* species. In southern Mexico and Central America the Euphorbiaceae ranks among the most important sources of latex in terms of numbers of species cited in the literature (several species of *Croton* and *Euphorbia* are cited in the literature as medicinal, although some are also poisonous if used incorrectly). A different source of rubber was a critical component of ancient Mesoamerican sacrificial rituals (e.g., in association with bloodletting, the ballgame, and in sacrificial offerings), and according Standley (1946:18-20), came from *Castilla elastica* (Moraceae).

Another elastic latex of great importance to indigenous peoples in and around the Maya region was, and continues to be, chicle or sapodilla (*Achras sapota*= *Manilkara sapote*, Sapotaceae) (Lundell 1933) . Chicle grows only in Mexico and Central America and Standley (1982:214-216) states that it was chewed by the Aztecs and that figures were modeled from it. Lundell (1933:18) states that the years from 1927-1929 represented peak levels of chicle production, in which more than 12 million pounds of the material were annually exported from the chicle-producing areas (of the Maya lowlands). There are small-scale attempts in some areas of Central America to reintroduce the use of this natural chewing gum into trade (e.g. *Belize Chicle*, produced by Ix Chel Farm). Chicle "kits" are available in the United States, as well as gums with "natural chicle."

As has been stated, latexes and resins are borne in distinctly different anatomical structures. Terpene resins and latexes share the isoprene molecule as the basic building block (derived from the mevalonic acid pathway) but in elastic latexes, among other features, polymers are much longer than in terpene resins and possess different structural configurations. The presence of *cis*-polyisoprenoids indicates elastic qualities, whereas *trans*-polyisoprenoids are nonelastic when solid (Coppen 1995:ix); both types of latex are significant in international trade (e.g., chicle, gutta-percha). According to Mann (1987:102), about one percent of all plant species have the capability to synthesize elastic *cis*-polyisoprenoids. Pure rubber is composed of many isoprene units, consisting of about 1500 to 60,000 isoprene units linked by *cis*- and/or *trans*- double bonds. I have included numerous latexes in Appendix 1 to demonstrate their medicinal importance and because I am not entirely certain that indigenous peoples drew, or draw, distinctions between the two materials; this difference may be a construct of modern science.

Summary of medicinal properties, pharmacological values, and perfumes of resins

In conjunction with Appendix 1, I have presented data on the plant families used by modern Maya as sources for natural resins and balsams. When possible, I have provided data on phytochemical constituents and pharmacological properties, and additional data on trade of resins and their respective products. The broad chemical classes of terpenes and phenolics in resins and balsams and their functions in Maya medicinal traditions correspond only weakly with those uses and functions in modern, industrialized society.

There are large differences between indigenous uses of resins compared to the use of the same resins in international trade. Modern Maya have a fairly simple set of uses for resinous exudates: as medicines and as incense. I found no indication that resins are used by the Maya as perfumes, nor that their chemical constituents are being isolated for this, or for a medical, purpose. The primary uses of resins does not appear to have changed over much over the last 500 hundred years (see Chapter IV); the

Maya have been fairly conservative in this respect. One aspect of the medicinal properties of resins not addressed in this paper, but certainly worth considering, is their "heat value" in Maya medicine. For instance, in Chapter IV I show that copal incense is considered "hot," hence its nourishing properties, but how does this fit into the larger scheme of traditional Maya medicine? We know that in some areas resins are used to reduce fever, but if a resin is considered "hot," how does it interface with the illness? That is, do "hot" resins combat high body temperatures induced by infection? Or are fevers sometimes classified as "cold?" What other, more subtle distinctions are made between these substances and the illnesses they remedy, and of what significance are they to traditional Maya medicine? Orellana (1987) examined prehispanic and colonial Maya medicine in highland Guatemala but to my knowledge, no systematic study of the medicinal systems of contemporary traditional Maya has been conducted, like that done by Weiss (Weiss 1998) for the Chatino of Oaxaca, Mexico (a non-Maya ethnic group). Undoubtedly, the medical anthropology of the Tzotzil-Tzetzal Maya region is better understood than that of Guatemalan Maya since it has been the subject of study by the Harvard Chiapas Study since the 1960s. No such study is exists in Guatemala.

Contemporary pharmaceutical investigation of Central American resins, and their chemical constituents, as medicines, seems virtually non-existent. In the past, resins were well incorporated into the *materia medica* of Western orthodox medicine, but today medical applications of the majority of resins from the Americas (with the exception of the Pinaceae) appears to be largely neglected or ignored. Balsam of Tolu is still used extensively in pharmaceutics as a feeble expectorant and catarrh inhalants, but is being replaced by synthetic mixtures (Coppen 1995:91). Although laboratory analyses of the anti-microbial and properties of Old World resins are taking place, I do not know of any medicines that have been manufactured as a results of these studies. The apparent anti-inflammatory, alterative, vulnerary, and fever-reducing properties of New World resins remain largely unexplored as viable alternatives to traditional or synthetic remedies used in industrialized nations. The Burseraceae, by virtue of its importance in Maya medicine, may warrant deeper investigation as evidenced by recent "alternative" products such as the pain reliever derived from frankincense. At the moment, there is a growing interest by some segments of the modern world in the investigation of novel secondary plant compounds found in tropical plants, which may herald a return to, or discovery of, some natural plant products. The rate and scale of investigation into the activity of resinous compounds, however, appears insignificant in the face of the traditional research goals of pharmaceutical companies: the identification, elucidation, and production of secondary plant compounds, and the development of synthetic replacements, as drugs for cancer and other life-threatening diseases, or for clinical depression. The natural food and health industry is the leading promoter of natural resins in "traditional" remedies and perhaps its influence will stimulate greater research into the utility of natural plant exudates as medicines. The prevalence of natural resins in modern Maya medicine may signal an untapped medicinal resource and is one that merits greater attention by the modern, industrialized world.

Summary of international trade of resins

As indicated throughout this study, the volume and values of resins in production and trade, both domestic and foreign, from southern Mexico and Central America, specifically in the Maya cultural region, is not well known. If regional trade patterns and taxonomic sources (wild or cultivated) can be determined in the future, it might be possible to explore how Maya perceptions of resin qualities and economic value affects collection, trade, and consumption. It was hoped that by examining data related to international trade of resins from southern Mexico, Guatemala, Belize, Honsuras, and El Salvador, some modern "end products" in the industrialized world could be identified and traced back to their sources, but industry reports and governments reports from the northern Latin American countries are not easily accessible or are lacking. Pine tree resin products are clearly significant in domestic and international markets, as turpentine and distillation products, and statistics on volume, application, and consumption rates, are relatively easy to obtain. In contrast, it is not difficult to learn that *Myroxylon* and *Liquidambar* are the most important balsamic resin exudates from the tropical Americas, but vital yield and trade are barely forthcoming (Adamson 1971; Coppen 1995). These industry reviews both agree that perfume industry demands for consistent quality, availability, and attractive prices of raw materials is driving the move away from natural resins to synthetic substitutes. Despite the scant economic data, certain historical and commercial trends can be perceived.

Available data demonstrate that the resins from the Maya cultural region and South America were early discovered by the colonial Spaniards, and became highly esteemed for their medicinal properties, their role as perfumes, and other reputed virtues. Several of these exudates became part of medicinal preparations, especially cough syrups, in Europe and the United States, and some were registered in Western pharmacopoeias (Hale 1911; Tyler 1981; Evans 1996; Reynolds 1996). Today these natural plant commodities are less valuable as medicines in developed countries. According to Adamson's (1971) and Coppen's (1995) reports, however, resins are still significant sources of perfume fixatives and certain scent notes in the perfume industry but are in short supply. Unfortunately, neither author provides good documentation of the country of origin, quantities exported to Europe or the United States, or prices for raw or processed materials. Adamson (1971) could not supply these details but states that

> The perfume industry is essentially a conservative one: having found a successful blend they will be prepared to pay a high price for any one ingredient rather than risk the dissatisfaction of consumers by either introducing a susbtitute, whether natural or synthetic, or by leaving the ingredient in question out of the compound completely. However, given a rising price together with difficulties in supply, perfume compounders will gradually use less and less of that particular ingredient in their composition until the time comes when demand has dropped almost to zero.

This statement provides some hope that resins from the Americas will remain important to the perfume industry, but apparently short supplies, rather than the synthesis of aromatic compounds as replacements for natural perfumes, is a more important issue. Adamson (1971) leaves open the question of future replacement by synthetics of dwindling resinous compounds.

Although there are indications that the decline in the importance of natural terpene and phenolic plant exudates in developed countries has been gradual, it is difficult to predict the economic and social consequences of a complete and rapid replacement of Mexican and Central American resins by laboratory or factory produced substitutes. Adamson (1971) stated that some Central American countries, like El Salvador, currently export most of their *Myroxylon balsamum* var. *pereirae* balsam. Recall that total purchases of the balsam from source countries were as large as fifty tons per year at the end of the 1960s (Coppen 1995:91). *Myroxylon balsamum* is also identified as a notable import commodity but the values for each are not determined separately (Coppen 1995:91). The potential revenue from resin exports can be enormous for a small country like El Salvador; dropping export values could present a significant challenge to their national economy.

One can see that resin exudates are notable commodities in Maya trade and economy, and a significant plant product in their repertoire of botanical medicines. Even if an international market for natural plant exudates ceases to exist, Maya use of resins will continue, because their presence and use is so firmly entrenched in Maya society. The roles of resins in traditional Maya medicinal practices, as well as in traditional Maya religion, ensures that plant exudates will prevail as economically important botanical products in that society.

Chapter V. Food for the Gods: Uses and Sources of Copal Pom/ Incense in the Maya Area

INTRODUCTION

This chapter focuses on the ritual, medicinal, and domestic properties and uses of plant resins which function specifically as incense in Middle and Central America. It is the first systematic study of plant resins in indigenous American cultures to be conducted. Five distinct Maya groups, the Q'eqchi', Ch'ortí, K'iche', Lakandon, and Tzotzil, act as cultural focal points from which to assess and discuss the salient features and roles of plant resins, particularly as incense. Each of these five groups, distinguished from each other primarily by language, geographical locations, degrees of modernity, and other characteristics, will be identified, and then the uses and concepts of resins within each will be presented and discussed. Complex concepts emerge, in which the roles of resins extend into the realms of Mayan natural resource use and management, religion, social organization, and medicine. Resins, by virtue of their historical association with divine communication, as well as their medicinal properties, are not mere plant products but possess profound, multiple meanings to the Maya.

Numerous questions can be asked about plant resins. Which resin-yielding floral resources are utilized by the Maya? What attributes and properties are conferred upon plant resins, in what contexts, and to what ends? Why is incense such an important commodity in the Maya economy? How might we compare knowledge of modern resins to archaeological artifacts and their contexts? I present modern-day use of resins in southern Mexico and Central America, identify numerous plant sources, and seek to identify how the Maya perceive ritual properties and functions of resins. It is at once an intriguing and challenging task, because of the complexity and depth of

Maya religious traditions and because of the oft-touched upon but little explored cosmological nature of resins in ethnographies concerning the Maya. Certain plant resins appear to be held in higher favor than others, depending upon the ethnic group and its geographical location. Although the vegetation of the Maya cultural area (ranging from southern Mexico to Nicaragua) has been altered over the last 500 hundred years, numerous Colonial sources confirm that many of the current uses and sources of incense resins by native Maya are the same as those of five hundred years ago. Plant resins remain intimately tied to Maya cosmological paradigms, which, in turn, affect social relationships, medicinal traditions, and religious worship. By examining plant resin use, one can gain insight into the Maya world, and come to appreciate the use and meanings of this particular natural plant product.

The type of plant resins discussed here are frequently sticky, often aromatic substances which exude from tree trunks, and generally consist of a complex mixture of volatile and nonvolatile chemical compounds emitted in response to injury, herbivore attack, or to human agency. Copal is a Nahuatl term (Sahagún 1950-1982) used by the Maya to indicate incense made from plant resins. Copal is well known in the markets and churches of southern Mexico and Central American societies and is best known for its use as an incense in traditional and Catholic religious practices. While several distinct plant taxa are presently used as sources of natural resin, the use of copal incense, or *pom* (a Maya term used in specific localities), as it is known by different Maya groups, precedes the arrival of the Spanish to the Americas by at least a millenia (Linda Schele, pers. comm.). Modern ethnographic sources also record the presence of copal as an important element in both religious contexts and indigenous *materia medica*, the latter of which I have addressed elsewhere (Chapter IV). The diverse plant sources and uses of copal located in modern ethnographic sources and documents presented in Appendices 1 demonstrates that the use of plant resins as incense and medicines continues to be widespread and well established in the Maya cultural region (throughout the Americas, in fact), in conjunction with both indigenous and Hispanic religious traditions and customs. The following is a brief introduction to the ethnic Maya groups discussed in this study, and to the state of literature, both ethnobotanical and ethnographic. Each group is initially presented separately, for evidence of copal use, sources, and functions. Later, the most salient shared features of copal use among the Maya are reviewed and I argue that copal is a natural substance which has been too long ignored as a significant indigenous element.

Several concepts of the role of resins in traditional religious practices are presented and discussed. The most conspicuous properties of copal incense are as:

1) An initiator of communication or contact events with Maya divinities and ancestors
2) A purifier of ritual and healing space
3) A gift, payment, or sacrifice, in ongoing reciprocation for a family's safety from harm and illness, favorable rains, and good crops. Copal is also used to banish fear.

ETHNOGRAPHY AND ETHNOBOTANY OF PLANT RESINS: METHODS

Politically speaking, all the Maya are located within the countries of Mexico and Guatemala, Belize and small parts of Honduras and El Salvador. Mexico is not considered to be part of Central America. Central America is a political and/or geographic term composed of the countries of Guatemala, Belize, Honduras, El Salvador, Nicaragua and Costa Rica. All geographic areas covered by my discussion are presented in Fig. 47, and include southern Mexico, Guatemala, Belize, El Salvador and Honduras. A vegetation map of the region is given in Fig. 48.

There are approximately thirty Mayan languages currently spoken across Central America (Coe 1993:27). This number indicates the diversity and degree of heterogeneity within Maya society. Five ethnic Maya groups are scrutinized here. These are the 1) Q'eqchi' of the department of Alta Verapaz, 2) the K'iche' of the department of Quiché, 3) the Ch'ortí of the department Chiquimula, all in Guatemala and 4) the Lakandon, and 5) Tzotzil Maya of the state of Chiapas, Mexico (Fig. 47). The data available from these Maya language groups serve as an introduction and template for discussion of certain major concepts associated with copal. There are, of course, differences as well as similarities between these groups, which may help to deepen our understanding of copal in these indigenous societies. Alcorn's (1984) seminal work on the Huastec Maya of central-coastal Mexico, provides valuable corresponding evidence of sources and concepts associated with copal incense, but is not discussed at length here, as the Huastec reside outside the geographic area outlined above. Data from Alcorn's work is, however, presented in Appendix 1.

The Q'eqchi' Maya constitute the fourth largest language group in Guatemala (Parra Novo 1995), but are less well studied - ethnographically - than the neighboring K'iche' Maya to the west, in the highlands. The majority of Q'eqchi' reside in the department of Alta Verapaz, close to the department of Petén, although a large contingent migrated to Belize in the late 1800s. Several interesting works on this populous group have been published in the last thirty years (e. g., Carter 1969; Cruz Torres 1967; Estrada-Monroy 1979; Estrada Monroy 1990; Pacheco 1988; Wilson 1995); scientific conservation organizations are forming and projects conducted (e.g., cloud forest conservation, Proyecto Ecológico Quetzal), and an ethnobotanical study of Q'eqchi' migration and adaptation to new botanical environments is underway (Darron Collins, Tulane University, pers. comm., 1998). Fieldwork in Lanquín, Alta

Verapaz, indicated that resin and copal collection and use is significant in this small town.

The Ch'orti Maya of the department of Chiquimula, located in southeastern Guatemala, close to the Honduran border, were studied by Wisdom (Wisdom 1940) in the 1930s and his work constitutes one of the few ethnographic sources on this language group. The numbers of Ch'ortí -speaking people had greatly decreased by the time of Wisdom's study and it is not known how the language or customs fare at this time. It may be that certain rituals and beliefs exist despite the potential loss of the language. The Ch'ortí provide some interesting information about early twentieth-century uses of copal, and some insight into copal's domestic and ritual roles.

The K'iche' Maya, of the western highlands of Guatemala, have been studied for over a century (e.g., Tax 1937; Bunzel 1967; Orellana, 1987; Tedlock, 1985; B. Tedlock 1992). There are no known ethnobotanical treatments on this language group. References to copal (and resins in general) are often buried deep within the ethnographic literature but with little discussion of the significance of plant resins. It is from such sources as Tedlock (1985), though, that copal becomes a bit more recognizable as a sacred material, possessing an animating nature akin to that of blood.

The Lakandon of southern Chiapas, Mexico, reside close to the base of the Yucatán peninsula and the department of Petén, Guatemala, and have another unique cultural history, and have permitted few scholars into their community. Yet, ethnographic evidence is strong that certain of their ritual customs are similar to those recorded in the sixteenth century (Tozzer 1907; Tozzer 1941; McGee 1990); they are now a very small ethnic group and rapidly changing, dispensing with many of their old ways and beliefs.

The ethnobotany and ethnography of the Tzotzil-speaking Maya, Chiapas, Mexico, are also, like the K'iche', the focus of much attention by scholars. Among the most important ethnobotanical works in Mexico and Central America, and in the Americas as a whole, is Breedlove and Laughlin's *The Flowering of Man: A Tzotzil Botany of Zinacantán* (1993; see also Berlin *et al.* 1974). The discussion of plant resins in Zincantán, Chiapas, relies heavily upon this source. Vogt's *Tortillas for the Gods: A Symbolic Analysis of Zinacanteco Rituals* (Vogt 1976) is also a valuable source. Gossen's wonderful studies of the Chamula Maya, also Tzotzil speakers of the central highlands of Chiapas, especially *Chamulas in the World of the Sun: Time and Space in a Maya Oral Tradition* (Gossen 1974), includes important folklore on plant resins.

It was found that the use of copal is part of a larger pan-Maya belief in the transformative actions and processes occurring during ceremonial events. This principle is critical to an understanding of copal in both modern and ancient Maya societies. As I review the data for each group considered here, I present examples of these kinds of transformations. I discuss the transformative principle more fully in the text.

A wealth of sources were examined, including indigenous documents and traditional mytho-historical accounts (e.g., *Popul Wuj*), colonial reports or *relaciones*, early descriptions of New World vegetation, and the earliest and most recent ethnographies and descriptions of indigenous Maya cultures. Chapter Four describes resin sources in the Maya cultural region in order to demonstrate the widespread pattern of utilization of resins, as well as their diverse plant origins. It was found that copal use among the colonial Mexican Nahua (or Aztecs) was widespread and appeared to share certain features with those of the Maya, but in order to maintain clarity and focus, the ethnographic discussion is restricted to the Maya. An examination of Maya concepts and uses of plant resins may permit some generalizations regarding their use in Central Mexico and future research will help to illuminate variations, similarities, and differences, in resin use and function, between these cultures.

Valuable resources were consulted at El Centro de Investigaciones Regionales de Mesoamerica (CIRMA), in Antigua, Guatemala, the Nettie Lee Benson Latin American Collection at the University of Texas at Austin, and the General Libraries at the University of Texas at Austin. Colonial sources include works by Landa (Tozzer 1941), *The Chilam Balam of Chumayel* (Edmonson, 1986), *The Chilam Balam of Tizimin* (Edmonson 1982), Roys' seminal work *The Ethno-Botany of the Maya* (Roys 1931, 1976), and the twentieth-century publications of colonial works by Sahagún, (1950-1982), Monardes (1925), Hernández (1943), and others. Nineteenth and twentieth-century ethnographies, scholarly reports, and other documents also served as sources for discussions of plants resins in indigenous cosmology, medicinal traditions, and domestic applications. In some instances, turn-of-the-century or Colonial sources have recently been printed or reprinted, resulting in a discrepancy between the date written and the date published. Literature from plant taxonomy, medical botany, and phytochemistry were searched for potential plant sources and applications of natural resins (Appendix 1). These data were considered when choosing and investigating potential field study sites in Guatemala.

Preliminary studies were conducted in Antigua, Guatemala, following a course in the Kaqchikel Maya language in the summer of 1993. A week of travel in the western highlands with a native Maya speaker was conducted at the end of the course. Copal collectors were sought and native markets visited for data on copal and resin exudate collection and processing. Numerous samples were purchased at this time as well. An additional two week trip was made in January, 1994 with the goals of collecting resin-producing plant taxa, and obtaining more information on resin uses and production centers. A four month period of field work from late January to mid-May, 1995, was conducted in order to ascertain where, why, and how resins are important to modern Maya today. Production methods and interviews with resin collectors were conducted whenever possible. The main body of interview data was collected in the western highlands of Guatemala and in the semi-tropical, mountainous area of Lanquín, Alta Verapaz, located in the eastern part of the same country.

The interview format was applied throughout all travels in Guatemala whenever possible . During each formal interview a list of prepared questions was asked and notes taken (Table 5.1, sections A and B). Somewhat similar queries were made of market vendors or a town inhabitants, during informal interviews (see Table 5.1, sections C and D). Questions were asked as befitted the social atmosphere; if an interviewee was comfortable with the author's presence and questions, as many inquiries as possible were made. In both informal and formal interviews, I attempted to ascertain the location and context of resin sources and collection, scale of collection (individual or group-finca-town basis), botanical source, collection and processing methods, final product, uses, marketing of product if possible, and discussion-comments. Permission to tape interviews was infrequently given but discussion of copal and other resins was usually granted.

Approximately 50 informal interviews of varying lengths and usefulness were obtained throughout all field studies, both in the highlands and lowlands of Guatemala. Only one person permitted a formal interview in the highlands (Department of Totonicopán). During the period of field-work in Lanquín, approximately five in-depth interviews on copal were granted (one formal, and several informal, interviews on the medicinal plants of the area were granted during this period, as well). One Lanquín informant was an obviously wealthy and respected man, probably Ladino, and was a fluent Q'eqchi' speaker, but it was not determined if he owned the land in the immediate vicinity of his house. His wife appeared to be an important healer in the town and often had a long line of patients to see. One wealthy Q'eqchi' family was interviewed at Semuc Champey, approximately eight kilometers from Lanquín. The family consisted of a husband and wife (she was the actual owner of the land), two sons, their wives, and a couple of very young children. They did not indicate that they hired any outside labor when planting or harvesting their crops of maize, cacao (chocolate), and copal. Another informant owned a finca within five kilometers of Lanquín and provided the most data on yield and service-exchange in Lanquín. Other interviews were granted by important townsmen, and while sometimes providing less specific information about resin collection and production, important issues regarding social relations, local land uses and history, and medicinal uses of resins were discussed. Of these type of interviewees, one was a resident of Cobán who told me that he owned much land in the Lanquín area. He was very well to do, but suffered from diabetes-related blindness, and respiratory problems. He knew a great deal about medicinal herbs and remedies, as well as some information about resins. His son was a Red Cross agent in the town and also owned a small tienda. A finquero who had a finca far into the Polochic Mountains, but lived in Cobán, was interviewed and his finca visited briefly. He knew very little about what the plants or rituals used by the Q'eqchi' who lived on his coffee finca. Only women were seen collecting resins in Lanquín and two permitted informal interviews.

Table 5.1 Interview questionnaire

A. Formal interview questionnaire: Collection methods and resin use

Date

Location (including distance from habitation), local language spoken

Collector's name and occupation

Collection method

Name given to resin

Frequency of collection

Identification method of collector

Form in which product sold (lumps, balls, puck-shaped pieces, logs, etc.)

Amount collected over year (collector's estimate), constraints

Product consumed domestically or sold in markets

If product sold in market, in which market was it sold (e.g., local or elsewhere)

Ownership of trees (this question was dropped immediately as it was deemed socially improper at the time)

B. Data collected by author at time of formal interview

Tree species

Color of resin

Physical state (liquid, semi-liquid, soft, hard, etc.)

Fragrance, if present (heavy, light, absent, etc.)

Habitat and associated vegetation

Circumference of tree

Estimated height

Seasonality of resin collection

Insects, birds, other creatures, seen on tree

Comments:

C. Informal interviews in markets and towns
Types and diversity of products

Application or use

Units typically sold (ounce, pound) and cost per unit

Sources (geographic)

D. Comments by author on products at time of informal interview
Color of resin

Physical state (liquid, semi-liquid, soft, hard, etc.)

Fragrance, if present (heavy, light, absent, etc.)

Other products sold by vendor

Frequency of product in market

Comments:

Orthography for Guatemalan Maya follows that adopted by Freidel *et al.* (1993) which is based on that of the Yukatek Maya language (Barrera-Vásquez 1980). This orthography is very similar to that proposed by the Proyecto Lingüistico Francisco Marroquín and the Academia de Lenguas Mayas, and others, and adapted in 1989 by the Ministry of Culture and Sports of Guatemala (cf., Margarita López Raquec's *Acerca de los alfabetos para escribir los idiomas Maya de Guatemala*, the official government publication of the alphabet and its history, as cited in Freidel *et al.*, 1993). It is important to note that former spellings of two Maya language groups in question, the Q'eqchi' and K'iche', were formerly written as Kekchi and Quiché. Following Wilson (1995), Guatemalan geographical names were retained, as in the Quiché department, but the new orthography is adopted for ethnic groups, e.g., K'iche'. In addition, the term copal is not italicized, as it has entered into mainstream English vocabulary; the widespread indigenous Maya term for copal is *pom*, and the term is italicized to mark it as such.

In many Central American countries the term "department" is used for major political-geographical regions instead of the United States term "state." A finca is a Spanish term for farm, an aldea is a very small, usually remote, community, and a municipio is a municipality. The terms Nahua and Maya refer to the cultures under consideration; Nahuatl and Mayan are corresponding adjectives (Schele and Miller 1986).

RESULTS AND DISCUSSION

Copal in modern Maya society

Following is a list of resins (Table 5.3) found to be used by each of the modern Maya groups under consideration. The data is based upon personal observations by the author, and upon identifications and reports provided in the phytochemical, ecological, and ethnographic literature. As one can see, there are numerous plant taxa serving as sources for resins, but not all are perceived or utilized as copal incense, an issue addressed throughout this study. Two plant families, the Burseraceae and Pinaceae, appear to be the primary sources of resins used as copal incense by the Maya. There is some indication that the Fabaceae (e.g., *Hymenaea courbaril*) and Hamamelidaceae (e.g., *Liquidambar styraciflua*) are of some importance as sources of resins but I found no overt evidence of their use during fieldwork.

Questions marks in the table indicate that the actual botanical source in question has not yet been verified, pending further field studies. The phytochemistry of each genus and many of the species has been addressed in Chapter IV. Resin samples (resins in a generic sense) obtained in the course of this study were submitted to chemical analysis and the reader will find the results and discussion in Chapter III.

Table 5.2 presents the incense specimens located and purchased by the author in the course of this study. There are at least eleven distinct types available in Guatemalan markets, varying in color, texture, density, hardness, and form. A full list of resins samples collected in the course of this study and their cultural functions is given in Appendix 2. Table 5.3 lists the total number of plant taxa encountered in the various literature. It is clear that diverse and numerous taxa are used by the Maya as incense.

Of issue in the preparation and application of resins is the degree and methods by which resins are heated prior to use as incense or medicinally, such as a skin application. The products resulting from the burning of resins and resinous woods include tar, an initial pyrolysate, and pitch. Pitch is derived from the further heating of the tar, resulting in further volatization. These derivatives are collectively known as pyroligenous substances (Pollard and Heron 1996:240). For instance, numerous sources considered below cite the use of warm "pitch" of a number of tree species but appear to be referring to warmed resin, not pitch as defined above. When resin is burned as incense, especially in caves or small spaces, it is likely that pyroligenous substances are generated, but these are very rarely the resin products used by the Maya in this study. There are examples, however, where the resins appear to be or are known to be boiled (with the addition of leaves, as in the K'iché region, or in water elsewhere) but in most cases it is not yet known why, or what benefits or properties this confers to the material in the eyes of the Maya who do so. In other instances, certain resins sold in markets bore some signs of possible heating and/or molding.

Fieldwork in Lanquín, Department of Alta Verapaz, Guatemala, revealed only one resin, copal *pom*, that is collected and used as incense. Methods of collection and processing of copal *pom* are both very simple and require little investment of human labor or capital. In the Department of Quiché, in the western highlands, only one form of resin technology, that of copal negro, was documented. The collection and processing of copal negro, in contrast to that of copal *pom*, requires several more steps and a greater investment of time and money. Copal negro is only one of several resin products found in indigenous highland markets, and every other type may involve different methods of collecting and processing. On the other hand, many resins appear to be sold in a crude form, indicating that few truly complex processes, if any, are applied. Packaging also varies between incense types; some products are wrapped in cacao or vine leaves, maize husks, or banana leaves, or no packaging at all. In sum, numerous and varied sources of resins are used as incense by modern Maya, as is discussed below.

Table 5.2 A list of plant exudate products types observed and/or collected in indigenous markets of Guatemala by the author

Common Name	Form and color	Application	Department in which purchased & ethnic group
Estoraque	Mix of clear resins and branchlets	incense	Totonicopán / K'iche'
Morambia	Large, red, unprocessed (?) globules, sometimes adhering to bark pieces	cough, respiratory illness	Totonicopán K'iche'
Copal criollo	Waxy, rounded, yellow globules	incense	Totonicopán/ K'iche', Huehuetenango/Mam
Copal negro (a)	Cigar-shaped brown resin, maize husk	incense	Chiquimula/Ch'ortí
Copal negro (b)	Discoid, mix of resin and bark or leaves, deep brown, sometimes with maize husk	incense	Totonicopán/ K'iche'; Huehuetenango/Mam
Copal amarillo (a)	Translucent, yellow crystalline chunks or powder	incense	Sacatepéquez, Sololá/, Chiquimula Kaqchikel; Chiquimula, Ch'ortí
Copal amarillo (b)	Small, waxy yellow drops of resin	incense	Totonicopán/ K'iche'
Copal blanco	Small blocks of sawdust, each piece encased in hard white covering, maize husk	incense	Chiquimula/Ch'ortí
Mirra	Bark chips	incense	Quetzaltenango/ K'iche'
Pom	Small mass of twigs bound by hard layer of resin; ball of composite materials	unknown	Quetzaltenago/ K'iche'
Trementina	Plain, unprocessed pine resin	raw material for copal	Quiché/ K'iche'

		negro, wounds	
Copal *pom*	Amorphous mass, yellowish-white, sticky	incense, all categories of use, skin parasites	Alta Verapaz/ Q'eqchi'
Ocote	Long, thin pieces of heavily resinous wood	illumination	Ubiquitous in study area
Unknown	Chips of aromatic wood	"Incense" substitute	Nebaj, Quiché

Table 5.3 Plant sources of resins used as incense by the five Maya ethnic groups under consideration

Maya language groups considered here (country)	**Reported plant source(s) and names**
Q'eqchi'(Guate.)	*Protium copal* (copal pom) *Bursera simaruba* (?) *Hymenaea courbaril*? (*pac*) *Liquidambar styraciflua*? (?)
K'iche' (Guate.)	*Bursera copallifera* *Pinus teocote*[6] *P. caribaea* *P. oocarpa* *Pinus* spp. *Liquidambar styraciflua* Other Burseraceae?
Ch'ortí (Guate.)	Burseraceae or Pinaceae
Tzotzil (Including Chamula, Zinacantán, and Larraínzar (Mex.)	*Bursera bipinnata* (*ach'el pom, tzo'ka pom,* mud pom) *B.excelsa* (*batz'i pom, muk'ta pom, pom ryox*) *B. simaruba* (*tzajal sal-te'*) *B. steyermarkii* (*pom ka' sotz' te'*, horse pom) Other Burseraceae? *Pinus ayacahuite* *P. michoacana* *P. montezumae* var. *rudis* *P. oaxacana* *P. oocarpa* *P. teocote* *Hymenaea courbaril (chilim te'*, powdery tree)

[6] McBryde(McBryde 1948):74) reports that the source of *ocote* in southern Guatemala is *Pinus teocote*. but Farjon *et al.* restrict the distribution of the species to Mexico, with only a small population crossing the Guatemala border.

	Styrax argenteus
Lakandon (Mex.)	*Protium* spp. *Pinus* spp.

General resin extraction methods by the Maya

Resin collection among the Maya falls into two broad categories — "tapping" the living trees or collecting wood from standing, living trees. The primary method of extraction by the Maya is to make incisions or shallow cuts to the bark of a tree. The exudate issues forth as droplets, large grains, or as flows. In contrast, some resin-producing taxa in Asia, such as members of the Dipterocarpaceae, have boxes literally chopped into the trunk. Once the boxes are excavated, fires are built within; the heated resin within the surrounding wood pools in the box and is collected when cooled (Gianno 1990). Collectors have also taken advantage of the capacity of certain neotropical genera, especially those in the Fabaceae, to produce huge bodies of non-exuded resin within their heartwood. In Mexico, the heartwood of *Hymenaea courbaril* may be exposed upon decay or felling and the resin-saturated wood is removed and either sold to traders or used by the collectors (Jean Langeheim, pers. comm.). This method appears to be uncommon among Guatemalan Maya. While no non-living specimens of trees with large inclusions of resins were observed by the author, signs of the collection of the highly resinous wood from living trees of *Pinus* were common in the western Guatemalan highlands.

In contrast to this method of resin-source management, however, observations were made in the western highlands of Guatemala of pine trees with massive damage to both the bark and the wood. The author observed standing trees with huge portions of the wood removed (see Fig. 49) The wood is removed with machete or ax, and chopped into large splinters or shards of wood, which are known as *ocote* (a word borrowed from the Nahuatl language). The tree is left standing, at least temporarily; I was unable to determine the eventual fate of trees treated in this manner. In Guatemala, the pieces of wood from *Pinus* are very common in the markets, and are used as tinder for fire or as torches (a similar product is known as fatwood in the United States). The Tzotzil Maya of Chiapas, Mexico, however, extract resinous compounds from wood by boiling the pieces in water and collecting the material which rises to the top; both the residue and the water are used medicinally. It is highly probable that in the past, with fewer population pressures, distribution and numbers of pines near habitations were greater than present. Trees may have been permitted to "rest," or the effects of cutting and/or resin collection may have been less obvious. Today, many trees are denuded of branches within twenty to forty feet of the base, probably for firewood or *ocote* (Fig. 50). It is possible that after all the branches within climbing distance are cut and removed, that a tree may then be temporarily harvested for *ocote* sections, then cut down for a larger, but short term, profit. It is not yet known how this method is perceived or experienced by local inhabitants, who spend an increasing amount of time harvesting firewood in the face of tremendous deforestation pressures throughout Guatemala. No government reports discussing this critical issue were located, but one indirect estimate of forest resource use in the region is provocative: as late as 1994, approximately 75% of households in the rural areas of western highland Guatemala were estimated to have no access to electricity and therefore relied on wood as their primary source of cooking fuel, in addition to its use as a construction material (*Encuesta Nacional Sociodemografica*, as cited in Islebe (1994:167-168)). Further studies may reveal other collections practices. Obviously, the long term ramifications of such unsustainable collection methods are severe.

The Q'eqchi' Maya of the Department of Alta Verapaz, Guatemala

Geographical and historical introduction to the field site of Lanquín

Geographically, the Department of Alta Verapaz (Figs. 51, 52), where a great number of Q'eqchi' live, straddles several ecosystems and is one of the few departments in Guatemala to possess such a high diversity of distinct ecosystems and floras, although the Central Intelligence Agency (1972) vegetation map for the department only gives a few ecosystems (consisting of "oak scrub, with grassland and patches of forest" at higher altitudes, and "broadleaf evergreen and deciduous forest and scrub and grassland" at lower altitudes). The author observed that in the western part of the department, mixed forests predominate (pines and liquidambar), while to the east and south, short-stature cloud forests (oaks and sub-tropical species) cluster on mountain tops. As the altitude gradually declines, the vegetation gives way to subtropical rainforests and then to coastal shelf and riverine habitats. In the northern section of the department the vegetation quickly becomes similar to that of the low-lying Petén, which lies to the north. The convergence of the Sierra de Chamá, the Polochic Mountains, the Maya Mountains, and the Petén, as well as the influence of the nearby Atlantic in the eastern regions of Alta Verapaz region makes for a highly diverse array of ecosystems. Soils vary, consisting largely of Cretaceous marine clastics (Guatemala 1966) and some volcanic deposits, both easily eroded. Much of the area is punctuated by sharp peaks and slopes of karst terrain.

The history of the Q'eqchi', and the Alta Verapaz region, too, is unusual, in that the cultural and economic history of the area has been distinct from that of the rest of the country since the arrival of the Spanish. Alta Verapaz was essentially isolated in the initial part of the Colonial period due to Bartolomé de Las Casas' largely successful arguments for peaceful conversion and absence of a military occupation of the region during the sixteenth century.[7] This historical precedent resulted in a temporary cultural "pocket," in which the Q'eqchi' were sealed off from many social and economic interactions with the Spanish. In 1821, coincident with Guatemalan independence from Spain, native Q'eqchi' landowners were stripped of their holdings by the Ladino government. In the late 1860s and '70s, government policies encouraged private development of coffee fincas (many of which were former native landholdings) in Alta Verapaz by Germans. The remoteness of the region, and its unusual history, has resulted in a history and ethnic presence very different from the typical tourist-assailed areas of the western Guatemalan highlands. Religious practices of many Q'eqchi', especially in remote areas, are rich in tradition, and possibly retain some autochthonous elements that are less affected by Catholic and Protestant doctrines than in the western highlands. More relevant to this study is the fact that in eastern Alta Verapaz the use of agricultural rituals appears to be fairly common and the use of medicinal plants in place of Western medicines is quite significant, especially as there are few medical doctors and many Q'eqchi' live at or below poverty level. Nevertheless, the department of Alta Verapaz is rich in the production of coffee, cardamom, cacao (chocolate), maize, beans, rice, henequen, chile, yuca, hats made of rushes, and copal *pom* (Gall 1976).

While conducting literature research an important source on Guatemalan trade in the sixteenth century, *A Tumpline Economy* (Feldman 1985), indicated the town of

[7] The Alta Verapaz was apparently inhabited by Chol, Manché, and Q'eqchi' Maya, each possessing a distinctive language. During the Colonial period the Chol and Lakandon (from present day Mexico, by the Usumacinta River) made military forays into the *cabacera* (department capital) of Cobán; as the Chol died out or migrated over time the Q'eqchi' came to inhabit most of the department, and today they reach as far north as southern Chiapas and as far east as Belize (King 1974; Sapper 1985).

Cahabón (about twenty to twenty five kilometers from Lanquín, Fig. 51) was one of only four sites in Guatemala which produced plant resins during the Spanish Colonial period (Feldman 1985:103) and indicated the source as *Protium copal*. *Liquidambar styraciflua* was also a common resin source in the Verapaz region at the time (Montero Miranda 1954: Capitulo 20), but was reputedly restricted to the area near Rabinal (see Fig. 51) (Feldman 1985:80). In the sixteenth century Lanquín was noted for large game animal products (Feldman 1978:9), cotton production, and weaving (Feldman 1985:59). Some data on tribute numbers and payments are provided as well (e.g., Feldman 1978:35, Table 5; 79, Table 15).[8]

Personal field observations conducted in January, 1994, confirmed that copal *pom* production is still very important in the department of Alta Verapaz, especially in the nearby town of San Augustín Lanquín, or Lanquín, as it is more commonly known. (Evidence for collection of *Liquidambar* balsam collections was not found at that time.) A statement by Standley and Steyermark (1946) provided confirmation that copal collection had been important in the early twentieth century: "The copal of Guatemala markets is said to come in large part from the lowlands of Alta Verapaz, whence it is carried on men's backs to all parts of the republic." It was determined that Lanquín would be the focus of the next field research period because of its location in a province indicated to be a significant source of resins prior to and shortly after the arrival of the Spanish, and because of the potential importance of copal

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[8] It is not entirely clear that Lanquín, or Cahabón, for that matter, were settlements prior to Spanish evangelization. It is possible that the original inhabitants of the area were Chol Maya (see King 1974 for a better introduction into the subject of linguistic development), gradually replaced or displaced by Q'eqchi' speakers over time, or alternatively, that Maya from elsewhere in the department were organized and brought into the area by the Catholic Church. A common means of administering to the often far-flung Maya of Alta Verapaz, who tended not to live in large communities, was to organize rural residents into *reducciones*, or settlements. Numerous reports from the area lament that conversion was difficult, especially as so many Maya refused to live in the towns created for them and as they were always running away.

sources in the present period. Despite recent limited exposure to outsiders, many Q'eqchi', especially those people from the aldeas and outlying fincas, have never seen a white foreigner before. Lanquín serves as a unique site from which to begin to view plant resin technology among contemporary and historical Maya societies, because of a combination of factors, including relative remoteness, limited contact with foreigners, the extensive occurrence of copal trees in and around Lanquín, the few ethnographies dealing with the region, the historical significance of the town as a copal source, and the apparent reliance upon copal *pom* by the townspeople.

There is a single road into Lanquín from National Route 5 (from Cobán), which continues to Cahabón, where it ends. A rough dirt road leading south out of Lanquín (past Semuc Champey) leads deep into the Polochic Mountains to the south and southeast, where it becomes a mere track leading to seasonal roads, other tracks, and walking trails through the Polochic Mountains to Lago Izabal and southern Belize. Directly to the east lies the Sierra de Santa Cruz, and to the north, the last vestiges of the Sierra de Chamá and southernmost moist lowlands of the Petén. There is bus service from Cobán to Lanquín and Cahabón and back three times a day. Few excursion vehicles travel along the difficult road to Lanquín, and even fewer travel more deeply into the interior, where large fincas and plantations lay. Most vehicles found on the road are transport trucks and small pickup trucks. The local soda vender can also be occasionally spotted on the more passable road to these fincas.

Lanquín lies approximately 65-68 km (ca. 40 miles) east of the province capital at Cobán, and just north of the Polochic Mountains. Lanquín is situated in an area where the altitude drops from an average 1200-2100 meters above sea level to 150 to 300 meters in a matter of kilometers; it falls on the cusp of the mountainous limestone features of the Sierra de Chamá, the southern foot of the Petén and Belize lowlands, and the grassy scrublands of the Cahabón-Río Polochic-Lago Izabal watershed. Vegetation and land use at the higher elevations above Lanquín, closest to the single road in the area, was characterized by coffee fincas, softwood (*Pinus* spp.) plantations, cattle farms, and milpa plots. In the lower elevations and in the Lanquín environs, annato or achiote (*Bixa orellana*, Bixaceae), cardamom (*Elettaria cardamomum*, Zingerberaceae), coffee (*Coffea arabica*, Rubiaceae), and cacao (*Theobroma cacao*, Sterculiaceae) plantations were seen to be interspersed with milpa plots. The Lanquín River emanates from the Cave of Lanquín, about a kilometer from town environs, and runs just north of the town itself, which is located on a plateau above the river. The Lanquín is an important tributary of the Cahabón River, a large river emptying into Lago Izabal to the south-east, after a long journey from Cobán and through the Polochic Mountains. Rainfall estimates for the local area were not available but were reported for the department as approximately 2,023.5 mm annually in 1961 (Gall 1976). Colonial records state the area is "tierra caliente." The general rainy season is from May to January. The period of fieldwork fell within the dry period (February to April), which by all accounts was drier than most years. Occasional rain storms of great magnitude occurred, but rainfall did not occur everyday as usual. Burning of milpa and grasslands in the entire department was especially prevalent that season, and reached dangerous proportions in the western highlands as well.

Lanquín is one of the oldest *municipios* or municipalities of Alta Verapaz, and is located in the southeast quadrant of the department. It is approximately 208 km^2 in area (Gall 1976). It has two natural sites of great importance to the growing tourist economy. The first site is a national park called Las Grutas Lanquín (or Caves of Lanquín), with a series of small caves where rituals are still occasionally carried out (this feature is not well known). There is an important bat sanctuary, and the cave is also the source of the Río Lanquín. The second site, Semuc Champey, is a unique formation: two rivers converge at the same site, but one river, the Río Cahabón, plunges below a limestone platform, while the second river flows on top. About 150 yards below the conjunction, the rivers converge again, their waters finally mixing. There is a current move to have it declared a national park as well. There is a privately-owned sacred cave nearby that has been visited by few white people. This site will be considered later. The predominant language in the municipality is Q'eqchi' Maya. The nearest large town is also the name of the same municipio, Cahabón. Both towns are recorded in Colonial sources as economically important centers for the production of cotton and other important tribute items.

Lanquín is unique in that it has only recently acquired status as a tourist destination along the "Ruta Maya," or the most popular travel route for foreign tourists. Visitors must travel three and one-half hours from the municipio's capital at Cobán by bus on a difficult road to reach Lanquín. In recent years, tourist visits to both the town and the nearby waterfall of Semuc Champey have increased dramatically and Lanquín possesses the only accommodations available to the itinerant traveler for miles around. Semuc Champey (described above), is approximately eight kilometers south of Lanquín, and is a site of unusual flora and fauna. Only Standley and Steyermark (1946) are known to have collected in the area. Today the surrounding mountainsides are under heavy pressure as land for new milpa is cultivated (Fig. 53). At the time of this study, there were unconfirmed rumors that the Guatemalan government had plans to develop the area as a tourist "theme park." The community structure of the forest and fauna of Semuc Champey should be examined before it becomes irrevocably eroded. At Las Grutas de Lanquín, just outside of Lanquín, some unusual orchids and members of the Euphorbiaceae still reside near the caves, and much of the hills immediately surrounding them are covered with copal pom.

Lanquín has approximately 11,550 inhabitants, nearly 10% of whom live in the urban environs. In 1994, 97% of the inhabitants were indigenous and only 7% or so spoke Spanish. The rate of growth from the 1981 population census was about 10% (unpublished census data, courtesy of Richard B. Adams, March 4, 1998, pers. comm. Any errors are mine.). Several Ladino families live there also and appear to hold the most important community and town positions, such as priest, mayor, and so forth. Ladinos also appear to own, or at least manage, the major businesses in town, which include a hardware store, a few very small restaurants, several tiendas selling sodas, snacks, and some dry goods, a bakery, and a very small pharmacy. There is also a very busy medium-sized almacén (store) on the single main street where "exotic" items like bottled water, soda, ice cream, cheese, candies, and a wide variety of snack foods like crackers, and candies can be purchased. The almacén also appeared to be a staging point for the trade and transport of coffee beans from the interior, for it was the sole place in Lanquín where coffee and other crops were dropped off and stored in preparation for transport to Cobán and elsewhere, by bus and pick up trucks. It was not clear if the almacén purchased these goods or merely stored them for finca owners. The front of the almacén also served as the "bus station" in town. In 1995, electricity was supplied by a diesel-run generator only from the hours of six to nine in the evening and only in the immediate vicinity of the town. The almacén possessed the only phone in Lanquín at the time, and service depended on sunlight, as it was powered by solar battery cells; it was often out of service and very few Lanquiñeros could afford the cost of phone calls anyway. The Catholic church in Lanquín is one of the most important sites in Lanquín and it was noted that some people attended church daily. Easter rituals were observed by the author in the church.

It is important to note here that Lanquín is the only community studied personally where the composite term "copal *pom*" was used. Copal is a term derived from the Nahuatl language of Central Mexico; many Nahuatl "loan" words can be found in modern Maya languages, and may be an artifact of ancient migrations of Mexican migrants into the Guatemala highlands and into southeastern Guatemala. The Verapaz region is a kind of language "pocket" in which the original Maya word for incense, *pom*, is retained but often modified by the addition of the term copal. I found in my discussions with the Q'eqchi', that women often used the term *pom* by itself, and that they were usually referring to a specific local tree species (identified below). Many of the men to whom I spoke used the composite term, or just copal, especially merchants or finca owners, and I frequently had to clarify whether we were speaking of the local resin source or of a different one. When the term copal was used alone by women, or other people whose first language is Q'eqchi', it was usually in the sense of incense derived from other sources, and often implied a "foreign" (outside the region) source. It is possible that since many Q'eqchi' women continue to speak only their native language, and little Spanish, that they retained the native term, while men, many of whom speak both Q'eqchi' and Spanish because of trade and migratory work, use the more widespread term. In all other Maya groups I encountered, copal was used to specify incense in general. More specific varieties or types of copal often possessed modifiers (e.g., copal negro, copal amarillo); these terms are discussed below. In deference to the Q'eqchi', I will use the term copal *pom* in this section. Elsewhere I will use copal as it is used in the general Mayan vernacular.

Taxonomic identities of copal pom trees

The copal *pom*-yielding trees in Lanquín have been identified as *Protium copal* (Burseraceae, Figs. 54, 55) and it is the dominant tree species in the immediate vicinity of the town center (one of my informants described the abundance of *pom* in the immediate vicinity of Lanquín as the "work of god and nature"). The trees are found on moist slopes scattered throughout both small and large fincas within the town's environs, and sometimes in large, solitary clumps in open areas, like the edges of house compounds, or densely interspersed with cacao trees and little undergrowth, away from houses. Outside of the immediate residential areas of town, copal *pom* trees are found bordering roadside fields (Fig. 55) and milpa edges. Copal *pom* trees are in fact usually left standing at any field edge. I also observed a clearing of secondary forest for milpa and found that while all other tree species were cleared a lone copal *pom* tree was left in place. Copal *pom* trees are not cut for firewood and therefore it may be possible that their distribution in and around the Lanquín area are the results of anthropogenic selection. In hedgerows, copal *pom* often grows with another burseraceous resin-producing tree: *Bursera simaruba*, commonly known as gumbo limbo, or "piel de la turista," in reference to the reddish peeling bark and its similarity to the sunburnt skin of tourists. *Bursera simaruba* is a tree commonly planted in hedgerows throughout Central America and the Caribbean[9]. The resin of this tree is also used medicinally.

One can often identify *Protium copal* around Lanquín simply by the breast-high cuts found on the light-colored bark and the occurrence of resin on these cuts (see Fig.

[9] Alcorn found that *Bursera graveolens*, a different species, was reproduced vegetatively by the Huastec Maya of Veracruz, Mexico (Alcorn 1984:468).

54).[10] Lanquíñeros say that this type of tree is the only one in the area used as a source for copal *pom*, although I was told that there are some people in remote aldeas who collect resins from pines (*Pinus* spp.). Pines, incidentally, are fairly uncommon in the immediate Lanquín area. A few can be found in cow pastures or on relatively undisturbed hillocks, and on the higher altitude slopes of the mountains, about five or six miles to the north. It is not known whether their absence is attributable to harvesting and cutting in the past, or to restricted habitat availability. Pines, *Liquidambar*, copal *pom*, and "balsams," were reported for the province by Montero de Miranda (Montero de Miranda: Capitulo 20) in the sixteenth century. He states that copal *pom* was planted and cultivated in the humid "hot country."

Degree of selection for desired properties in individual trees or within the Lanquín population of *Protium copal* is unknown, nor what kind of selection has occurred in the past. It may be possible that the Lanquin population of copal *pom* trees could be hundreds of years old. Next to nothing is known of the lifespan or population ecology of *Protium* in Central America.

Collecting season, methods, and processing of copal pom

I was informed that the greatest quantities of copal *pom* are collected during the rainy season (from June to January) but I observed collection of the resins toward the end of the dry season (late March and early April). I suspect that collection began

[10] The following technical characters aid in the identification of *P.copal*. The presence of large, odd-pinnate compound leaves with long-petiolate, mostly entire leaflets ten to eighteen centimeters long, small, perfect or polygamous flowers (four to five petals and eight to ten stamens), and a 1.5 to 3 cm. long drupaceous fruit with four to five (sometimes three) nutlets (see Standley 1946:442). In Lanquín, numerous tress were flowering in March, but no fruits were yet produced.

then because of the "rush" for copal *pom* incense as the spring planting rituals and the holy days of Easter (Semana Santa) approached, in which huge quantities of copal *pom* are burned. I explore this issue further below. Copal *pom* collectors say that during the dry season the copal *pom* trees are "using the sap" (directly equated with the resin) for growing flowers ("production") and few collections are made. Flowering usually begins in late February or March, and fruiting begins in May or June. It is not known to what degree the Q'eqchi' resin collectors understand the seasonal physiological production of resins, but when asked all stated that the trees need "to rest" at the end of the rainy season and that they require a good deal of humidity to produce the *pom*. Exudation rates increase dramatically as the dry season comes to an end, and more frequent collection begins close to the traditional planting time, near the end of April and beginning of May.

Copal *pom* collection and processing methods in Lanquín are simple. Copal *pom* is collected from *Protium copal* trees at least six inches in diameter. Before trees attain this size they are considered "too weak." One informant suggested that the tree is not tapped before it is ten years old. The larger a tree, the more copal *pom* it will produce, and collectors can make more incisions to a large tree without incurring lasting harm. There are no special criteria for tree selection. Any tree over the general six inch diameter is used. Most trees seen within the town limits were at least fifteen inches in diameter at breast height. If a tree is small, only a few incisions are made in the thin bark. These will generally begin at the base of the tree trunk, and on exposed roots. If a tree has not been tapped before, or if it is an old tapped tree, a very shallow oval-shaped cut is made in the thin bark - about 4 or 5 mm. deep, and 4 x 4 cm across, baring the yellowish wood below the bark (Fig. 57). A series of three or four such cuts can be made around the tree but the collector is careful not to "tire" the tree with too many. The long collection season (about eight months) ensures that a good deal of resin will be available but as stated previously, the Q'eqchi' have found that the tree can be overtaxed and resin production weakened. Therefore they are careful to monitor the tree's health and yield, and only resume active collection after the fruits of the tree have fallen (around June or July). After the cut is made the tree is then left alone for three or so days to permit enough resin to be secreted at the edges of the cuts when the original, or another, worker returns and uses a knife's edge to remove the accumulated resin Figs. 58-63). After collection, each cut is carefully extended vertically or a whole new set made, several centimeters above the previous ones. In this manner, a cut is extended over the rainy season to a length of about 50 cm. (I witnessed only much smaller cuts, the maximum a length of about 15 cm.). This collecting regime is apparently continuous throughout the rainy season, when volume is high. Two tools are used: one is a sharp metal knife, approximately 11-14 cm. long, and the other a thin wooden paddle on which the resin is laid, and then patted and shaped to a small degree (Figs. 15a-d). I was told the paddle was made from the wood of "madre de cacau" (*Gliricidia sepium*, Fabaceae). The paddle is laid flat in the hand like a board, and the collector scoops up the sticky, aromatic lumps from the tree, and wipes it onto the paddle with the knife in quick, practiced strokes. Each individual globule removed from the tree was small and probably would be considerably larger during the wet season. After each new clump of resin is applied to the paddle, it is gently patted and compressed with the knife. Some collectors display variation in their methods: one Q'eqchi' informant applied saliva to "keep the *pom* moist." A large amorphous lump of sticky, semi-solid copal is built up on the paddle, one layer pressed down upon the preceding one. Once a certain amount of copal is collected (generally when the paddle is full or becomes heavy (about 1/2 kilogram), the collector retires to an informal processing area. I was told that the *pom* almost always has bit of bark, dirt, and sometimes insects, in it and rarely is collected in a "clean form," but the price is not affected.

Collectors do not climb the tree to extend the incision area, as is the case for chicle extraction (*Manilkara sapota*, Sapotaceae).[11] The incision and collection method in Lanquín may or may not be sustainable, but in the long run it may be because it avoids completely injuring the vascular cambium of the tree. Although old, large trees may display a great deal of scar tissue from past incisions, little discernible damage is visible on the upper parts of the tree, which could be expected on a severely injured tree. Furthermore, one informant stated that the collectors learn to assess their tree's health and will often leave certain incisions or larger areas, to heal over, or "rest," even during the wet season.

Processing consists of transferring the lump of copal to a large leaf, where the sticky substance is shaped and molded into a round shape. The resin is wrapped within the leaf, and tied with what appears to be an aerial root part, or liana stem (unidentified). I was told that the rate at which the fragrance evaporates and the copal hardens (into a brittle, almost crystalline state) will differ depending on what kind of leaf was used for wrapping (this issue seemed somewhat moot at the time, as one informant explained that virtually all of the copal collected during my stay in Lanquín would be burned during the religious rituals; I suspect that storage properties are likely to be more important at other times of the year, when copal is transported to other

[11] Diagonal incisions are made to the trunk of these latex-bearing trees and these conduits converge into a single runnel which flows into a metal cup tacked into the tree. These incisions may continue to flow for up to some time. In certain areas, especially in the lowlands of the Atlantic coast, chicleros will climb as high as twenty five feet to make additional incisions in the tree (personal observation). "In British Honduras [modern-day Belize] the copal tree "is not bled in the same way as a rubber tree, but the bark is shaved" (Thompson 1939:104, as cited in Tozzer 1941:75, n. 338).

markets). Two plant species used as wrapping material were been observed: an unidentified member of the Araceae, called *pico de ave*, and cacao leaves (*Theobroma cacao*, Sterculiaceae). My interpreter told me that the leaf of the *pico* is preferred because it is soft and moist, and that copal keeps well when wrapped in it but that it was in short supply right then because of the dry season. Some vines that may have been *pico* were seen growing in leafy trees along the road to Cahabón, where it ran parallel to the Lanquín River, and where high humidity and fewer human activities permitted an increase in tropical plant species (specimens of this vine could not be obtained). I noted that the leaves were to be semi-succulent, with greater water content, more vascular fibers, and greater thickness than cacao leaves, perhaps offering better moisture retention, and longer storage properties.

When pico leaves are not available, large and fairly new cacao leaves are used (numerous tree species in the area produce abundant new leaves toward the end of the dry season). It is not known what determining factors guide leaf selection, if any, or the short and long term effects of the storage material on the copal (e.g., differences in leaf moisture retention over time, etc.). Cacao leaves may have symbolic associations with maize planting. New leaves are certainly more prevalent in late March, and early April, as the planting ceremonies and the religious holy days approach. The use of new leaves may be related to the fact that cacao domestication and cultivation has a long period of use in Maya culture, and is still held in very high esteem by the Q'eqchi'. Cultivation of the cacao fruit (the source of chocolate) is difficult and requires careful attention and because of its high monetary value, chocolate is considered a delicacy saved for special occasions. Use of new, orange-pink-colored cacao leaves (seen, most notably, in church crèches) may somehow be associated with the renewal of the planting season. Cacao leaves may be associated with both the annual agricultural ritual events and the most important Catholic event of the year, Semana Santa (Easter).[12] I was also told that the *pom* could be wrapped specially into any form I was interested in.

Once the copal is wrapped in a leaf, and tied, it is ready to be sold. The package weighs about 0.5 kilogram ("ún libre," the standard unit of measurement used by the Q'eqchi' with whom I spoke), and the resin is semi-soft to the touch and richly aromatic, even from a distance. At the time of this study, packages of copal seen at one finca and elsewhere in the town, tended to be sold in 1/2 kilogram quantities, though vendors will divide a package into small pieces for sale in the market, for use as incense, especially in the Easter rituals.

Copal collectors in Lanquín were all observed to be women and few children. Perhaps men also become involved in resin collection during the productive rainy season, but it is likely that their time is spent preparing, planting, and weeding the milpa, or working on the larger fincas of the wealthy Ladinos. Copal *pom* trees may be considered by the Lanquín Q'eqchi' to be part of the women's realm of plant cultivation and harvesting, since it is close to the home setting, and since women elsewhere in the region are responsible for garden crops near the house, such as yucca [*Yucca* spp., Agavaceae], manioc or cassava [*Manihot* spp., Euphorbiaceae], and bananas [*Musa* spp., Musaceae] (Wilson 1995: 103).

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[12] Both series of agricultural renewal and religious events are associated with this one to two month period, occurring sometime in late March and April, depending upon the weather and the ecclesiastical calendar. With planting of the milpa and onset of the rainy season, and the ritual rebirth of Christ in the Catholic tradition of Easter, it is a highly suitable setting for the burning of incense.

Yield, control, ownership, and management of copal pom sources

There was little variation in resin collection and processing as explained and demonstrated by the Lanquiñeros. There is, however, what appears to be a productive system of labor exchange and profit-sharing between at least two finca owners and their workers. The degree or type of kin and/or social relationship between property owners and the townspeople who collected resins on large tracts of land was not ascertained, and remains a question for future study. In Lanquín, as in many parts of Guatemala, entire families often live on the land of the finca owner[13], receiving a modest house in partial payment for their services during the harvest and at other times. Other forms of payment, perhaps in labor and services, may also be in effect. For instance, one finca owner, Don Agósto, lived at Finca Chitém, about two kilometers east of Lanquín, on the road to Cahabón. Don Agosto apparently ran a small, loosely organized supply shop from his house. This is not unusual: many laborers or milpa farmers nearby can avoid walking the distance into town by purchasing small items from Don Agosto. Among his wares were thirty five to forty packages of *pico*-wrapped copal pom, "ready to be sold in Cobán."

Lands in Lanquín appear to consist of both small landholders and large fincas with tenant farmers. Small landholdings appeared to be owned and farmed by Q'eqchi' or people of Ladino-German and/or Q'eqchi' descent, while large fincas were observed to belong to Ladinos or at least supervised by wealthy (often Protestant) Q'eqchi'. No data were collected pertaining to land ownership in the area, as initial contact with potential informants was based solely on the basis of resin research. It was deemed indiscreet to ask of such matters until the community was more comfortable with the primary research goals. It became clear that the lands of certain

[13] see King. 1974, for discussion of the abolishment of communally-held Indian land, and the effects on population demographics in the Alta Verapaz.

fincas were actually within the town vicinity. What were thought to be tiny "public" neighborhoods of the town proper were actually found to be clusters of settlements on finca lands. Moreover, it was found that tenant farmers may reside in a house in town and journey to their milpas at some distance, or may reside on finca lands, as did a Q'eqchi family that was interviewed. They lived in two small huts made of vertical tree branches and a thatched roof. One hut was used primarily for cooking and many domestic tasks, while the other hut served as the sleeping room. This family lived among a cluster of other such houses, just above the home of a family that may have been the owner or the manager of the finca. Their home and lives appeared quite involved with the person "in charge." Some people (especially men) stated that they hired themselves out at different times of the year, working on fincas planting, weeding, and harvesting the area's economically important crops of achiote, cardamom, and coffee. It is not known if workers are associated with particular fincas, or if they are forced to contribute a certain number of days work to a finca owner, as was once true in Alta Verapaz (King 1974). As can be seen, organization of lands and copal resources are therefore varied and diverse in the Lanquín region. Issues of control, ownership, and management of plant sources, both short and long term, including ranch owners, need to be investigated and defined.

Don Agosto stated that resin was collected from copal *pom* trees on his properties surrounding Lanquín, and whose number he estimated at perhaps 30,000. Many of the people who work for him as agricultural or manual laborers collected resin in return for half of the total amount collected at any one time.[14] The agreement

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[14] A potentially confusing factor involved in estimation of resin volumes involves units of time over which copal is collected. Don Agosto was probably speaking about rainy season collection, not of the dry-season. While currently lacking data to substantiate any theories, it might be that a still-considerable amount of copal is collected during the dry season since there were at least thirty parcels

permits each party to retain their own lot, or sell his or her shares of the resin product to whomever they care to at the going prices, either locally or elsewhere. Don Agosto calculated that his copal trees yielded about six kilograms of resin per one hundred trees during the rainy season. If Don Agósto's estimate is accepted, and his estimated total number of copal trees reduced to a more conservative 20,000 (assuming that not every individual in a population of copal trees will be tapped, due to age or accessibility), a net result of ca. 1200 kg of copal resin can be harvested from 100 *Protium copal* trees over a period of perhaps eight months. If each party receives half of the total resin collected, approximately 600 kg each, they possess a potentially valuable source of revenue, or a great deal of material for use as incense or medicine (prices are discussed below).

After supplying the finquero with half of the copal *pom* harvest, the collectors keep the rest and both parties are provided for. Collectors then have a variety of choices regarding the destination of their product: they can sell to a local tienda keeper, to a larger vendor in the bi-weekly market of Lanquín, or travel into Cobán (65-68 kilometers or ca. 40 miles) to sell their copal *pom*. Traveling to the capital of the department is an expensive prospect for many people of Lanquín and its surrounding aldeas and hamlets. One Ladino finca owner with whom I spoke kept part of his copal to sell to locals and the rest to sell in Cobán, where he could command a higher price than in Lanquín (he also had his own transportation, a rare luxury amongst most town inhabitants). It was observed that, especially along the dirt road to Semuc Champey, south of Lanquín, many copal *pom* trees showed signs of collection, indicating that inhabitants of outlying areas collect the resins as well. In these areas the copal *pom* trees were interspersed with crops of achiote, cardamom,

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within view at Don Agosto's at the time of the interview, each weighing at least 250 grams, and probably closer to 500.

and coffee, milpa, and several species of leguminous trees. Other tropical tree species were present as well. Patterns of land ownership or vegetation outside of Lanquín, especially on the old coffee fincas, are unknown at this date. Whether a collection agreement similar to that of landowners and tenants in Lanquín exists among the tenants, and the resin product sold in Lanquín, or whether this land is owned by Q'eqchi' farmers, is yet to be determined.

Prices for copal vary through the year and appear to be dependent both on availability (low during the dry season) and demand, near holy days and festivals. I was told by several informants that during the rainy season copal can sell in Lanquín for as little as seven to eight quetzales per 500 gms (average $1.36 US per half kilogram), at an exchange rate of 5.7Q per U. S. dollar, 1995), while in the dry season, especially during the Maya New Year (February), Easter Week (March or April), and just prior to the planting of maize (usually in the beginning of May), prices can soar to twelve to fifteen quetzales per 500 kgs (average $2.36 U. S. per half kilogram). One Lanquín vendor told me that she was selling Lanquín copal in Cobán for fifteen and sixteen quetzales per half kilo just before Easter Week. Given that a good wage for a skilled male worker in Lanquín is approximately fifteen quetzales per day, the purchase of 500 kgs of copal is a sizable purchase for a typical town inhabitant, or, conversely, a source of considerable revenue. As the copal *pom* trees were reputedly resting during the dry season, local market sources of the resin must have consisted of numerous but small recent collections, or calculated stockpiling (I was told that some collectors will attempt to "hoard" copal until it increases in price) from the previous rainy season. One informant related that in the 1970s, a half kilo of *pom* was valued at twenty five quetzales.

The value for production and yield can now be used and associated with potential monetary values. For instance, a total of 21,600Q per family or person can be calculated for a total season's worth of collecting. A family may conceivably choose to collect copal *pom* resins in one or the other season, depending on seasonal activities or cash needs. For example, seasonal fluctuations in copal prices for one half kilo of copal *pom* could result in a low 6Q per pound during the rainy season when supplies are reportedly common, yielding a potential value of 7200Q. On the other hand, if values are calculated for the dry season, when supplies are short and prices high, at a conservative 12Q per pound, a potential value of 14,400Q results. It is likely that at least part of the resin will be sold either locally, or outside of the Lanquín community, or be exchanged for food staples or other items of value. A seasonal total for a copal collector can be calculated to be somewhere in the range of 21,000Q. Of course, the question of real production values (including a time scale) remains to be proved.

The calculated value of a season's worth of collecting seems exceedingly high, and there is little visible demonstration of such wealth in the town or homes I visited. This may be, however, an artifact of my own cultural biases and lack of familiarity with the local economy. On the other hand, Don Agosto's original estimate of yield per tree could be grossly overestimated and therefore the actual value of a season's collection of copal *pom* far less than reckoned. Production levels may be in question, but the monetary values of the product are not, and still assure a good source of income to the Q'ekchi' collector. Numerous questions are raised but could not be answered in the alloted period of fieldwork. For instance, assuming that there is some substantial revenue raised from copal trade, what use is made of that money? What does it contribute to the average annual *per capita* income of the Lanquiñeros? How are yield values related to the sizes and uses of small and large landholdings? What proportion of land is occupied by copal trees in relation to that occupied by milpa, exotic crops, or grazing? The average Maya has to budget for the costs of maize seed, expensive ritual items, contributions to the church, medical attentions, and transportation, among other things. How does the cash value of copal fit into the Q'eqchi' Maya budget? Copal resin production may be a considerable factor in the economy of Lanquín, and further studies are suggested by these questions.

It is not clear how the *Protium copal* sources are managed in Lanquín and its environs. As noted before, large expanses of *P. copal* are found within the town boundaries. It appears that few other resin-producing tree species occur in the area (except, perhaps, for *Bursera simaruba*, but this seems to a minor source of resin). It is suspected that a long history of management has occurred but there is currently no way to investigate this issue (there may be data in the land grants and records in the town's archives—if any exist). An indirect piece of evidence for this suggestion is the Lanquiñero's relative unfamiliarity with resins from outside the town. All of the informants lumped the terms sap and resin together into one category and it is not clear whether Lanquiñeros actually distinguish between local resins and those from outside Lanquín, or even have much familiarity with or exposure to their uses. When asked why no other types of copal are found in Lanquín, one informant responded that Lanquín's copal *pom* "is the best," implying that there is no substitute for the local product (a similar claim was made for resin sample number KT 4, from the western highlands—see Appendix 2). Degree of familiarity and long-term use of such an important local plant product may imply some deliberate retention of it, thus influencing the single-product resin market in Lanquín and leaving little room for other resin types. It is also equally likely that while the flow of copal is unidirectional (out of Lanquín), the town is so saturated with its own local copal that few inhabitants would seek out new types in Cobán or elsewhere.

After my return from the field, a new ethnography on the Q'eqchi', *Maya Resurgence in Guatemala: Q'eqchi' Experiences* (Wilson 1995), was published in which the author describes three types of *pom* used in the San Juan Chamelco area near Cobán, the department's capital. Wilson provides the only indication I encountered that more than one kind of copal *pom* is used in the region (see next section). In my experience, copal *pom* from Lanquín is used for virtually all the same uses recorded in the highlands, but originates from only a single type of plant, and involves only one procedural step, rather than multiple stages of preparation and diverse plant sources, as was found in the highlands. Lanquiñeros do not "need" to distinguish between resins, nor do they attribute different properties or applications to them, instead, they utilize local copal *pom* in all its known use categories. One informant mentioned *copalché* (literally, "copal tree") as a source, but its sources, both geographic and botanical, were never determined. Another told me that he had seen yellow, red, white, and other various colors of incense in Cobán, but didn't know the names or process by which they were collected and processed, or where they were from. Standley and Steyermark (1946) reported the presence of another important resin-producing tree taxa in the area, *Hymenaea courbaril* (Fabaceae, subfamily Caesalpinioideae), but I was not able to locate the species in Alta Verapaz during the fieldwork period. The use of *Liquidambar* trees as resin sources in Alta Verapaz or near Lanquín remains unanswered for the present. As related earlier, numerous stands were seen during my travels in the department of Alta Verapaz, always at high, cool, and moist elevations, sometimes in the company of pine trees, but none showed visible signs of tapping. Some colonial sources state that the exudate of *Liquidambar* was used as a resin incense, and according to Standley and Steyermark (1946:427-429) and Standley (1982:317), large amounts of liquidambar resin were shipped to Spain from Central America and Mexico in the colonial period, though they do not name the specific locale or source of this data. The market at Cahabón needs to be investigated in regard to copal, as it, too, is reputedly a center for copal collection. It is located at even lower altitudes than Lanquín (600 to 300 meters above sea level), and on the edge of the coastal lowlands and low ridges. It is hoped that future studies will elucidate features of resin technology there for comparative purposes.

Resins in religious ceremonies, everyday life, and in medicinal treatments in Lanquín

At least a superficial comprehension of the Maya's veneration of maize is critical to an understanding of religious life, and the role of copal in that culture. To many Maya maize is not just an agricultural crop but an animated, living being. Maize is perceived as possessing a soul, and must be venerated, as must the gods who created it for human use. The perception of animation extends to nearly all physical objects and supernatural beings in the world. Differences and variations in specific rituals and beliefs between distinct Maya groups aside, the Q'eqchi' are subject to the same pressures perceived by most Maya across language groups: that in order to maintain the order of the universe and the germination and health of maize, the gods and ancestors must be fed and venerated, a topic I will address throughout the rest of this paper.[15] The gods, however, don't "eat" human food, but essences, as I will

[15] For an introduction to the significance of maize for the Q'eqchi' and other Maya cultures, I strongly recommend *Maya Resurgence in Guatemala: Q'eqchi' Experiences* (Wilson 1995), Vogt's *Tortillas for the Gods: A Symbolic Analysis of Zinacanteco Rituals* (1976), and Ventura's *The symbolism of Jakaltek Maya tree gourd vessels and corn drinks in Guatemala* (Ventura 1996).

demonstrate. Copal is considered one of the most sacred substances of all possible substances, yet few Westerners understand or appreciate its properties.

In their discussion of the Q'eqchi' spirit world, Carlson and Eachus (1977) discuss how the Q'eqchi' see themselves in the natural and supernatural world. They perceive their health, livelihood, and prosperity as intimately influenced by a "world of beings super-sensitive to being slighted." Three acts of service must be frequently enacted in order to maintain a happy relationship with these tempermental entities: 1) *mayejak*, "to give offerings" or *uc'uk* "to worship," 2) *wa'tesiink* "to feed," and 3) *rawasinkil*, "to counteract" (Carlson and Eachus 1977:39, old orthography). Wilson, however, defines two of these terms differently: *mayexak* is "to sacrifice," *wa'tesiink* retains the meaning "to feed," and *rawasinkil* is a rite performed to cure human *awas* (illnesses related to pregnancy and infancy) (Wilson 1995). As stated by Wilson, in his study of Q'eqchi' cultural resurgence, "among the Q'eqchi', rituals are life-giving activities, inseparable from everyday knowledge of fertility and health" (Wilson 1995:91). Certain sacred substances, such as copal and other ritual items, have great metaphysical power and are conceived of a possessing a benevolent spirit-soul, *šdiosil* (food crops also possess these souls). Copal can be offended and become 'sad.' If it, like other ritual objects, is mistreated, the spirit-soul is taken away by the gods, and the offender is likely to suffer (Carlson and Eachus 1977:47-49). These are rituals and concepts found throughout much of the Maya area, and I introduce them in order to bring the ritual nature of copal into focus.

Pom is considered to be an earthly substance which undergoes transformation —by burning— into a vaporous state which the invisible gods, saints, and other deities, can consume and be nourished by. The attitude with which these offerings (often called sacrifices) are made is a deferential one, in which the Q'eqchi' petitions the divine authorities for permission to use the natural resources of the region and community. Wilson (1995:75) calls the offerings "the basis for a subsistence-based 'moral economy,'" and explains that the petitioner, although in a subordinate role, hopes to negotiate a relationship with the recipient in which he or she is obligated to exert power on behalf of the giver. As Wilson aptly states, "In eating the offering of food, the consumer swallows the hook of responsibility. The offering, then, placates the [deities] but also contains elements of manipulation and egalitarianism" (Wilson 1995:75). According to one of Wilson's informants, *pom* is *xwa Qaawa'*, "the tortilla of our father." "*Pom* calls the spirit [*xmuhel*] of the mountain" (Wilson 1995:74). Copal *pom* not only feeds and invokes the presence of the gods, and sanctifies the ritual space and participants, but also sets up a leveling, reciprocal kind of influence between both human and god.

The advent of the growing season is a critical time for the Q'eqchi' and attended by much anxiety. They are concerned that the rains arrive on schedule and in ample quantity. Apparently there are community members who serve as planting advisors: they watch for changing weather signs indicating the coming of rain and examine the soil for particular characteristics which, interpreted overall, indicate whether planting, especially that of maize, can take place (I suspect that copal trees and the increasing volumes of exudate may also serve the Q'eqchi' as ecological clues for determining or predicting weather). At the time of planting, much copal is burned in the milpa itself. Q'eqchi' believe that the copious smoke pleases the gods and will bring rain to the milpa so the first seeds can grow. One informant told me that some milpas have little shrines in which copal is "fed" to the gods, prayers are said, and the good favor of the ancestors is invoked. Even if a milpa does not possess a shrine, great quantities of copal are burned, "carrying prayers" to the ancestors and gods.

During my stay in Lanquín I was invited to participate in a ceremony encompassing both *wa'tesiink* and *rawasinkil* rituals (in the Carlson-Eachus tradition). A turkey was sacrificed and offered to the gods, and then cooked for a ritual meal. Prior to consumption, a plateful of the meal was placed on the family altar, along with flowers and candles, and copious clouds of copal billowed from an incense burner (the copal was collected from the family's own trees). The food was offered again to both the gods and the family saints, and prayers recited. Prior to our eating, the men and I walked to a small, nearby cave. Women are usually excluded from this stage of the ceremony and I was fortunate to be allowed to join. In the deep recesses of the cave were signs of very recent offerings of copal and candles. Once again, food, candles, and copal were submitted. The ceremony was conducted in order to ask permission of the Q'eqchi' gods to sell part of the family's land, and to counteract any evil that might come from having strangers walk upon it recently (during property surveys). [16] It was an elaborate and expensive ceremony and undoubtedly there was more going on than I was able to comprehend. The event occurred just before Easter week as well, which is often a time in which rain-bringing ceremonies are conducted.

In his description of the "vigil for the maize seeds," Wilson (1995:96) states that a ritual specialist 'burns *pom* over the seeds, the altar and saint, and all those present. He petitions at the altar, giving notice to God, a local *tzuultaq'a* [an earth deity], and all the mountain spirits he knows of that they will plant the [maize] seeds in the morning. Father Sun, Mother Moon, and Venus are all invoked. *Pom* carries his message to the deities, who are pleased by the offering. *Pom* feeds the seed as well as

[16] As we left the cave, I conversationally asked where rain comes from, and was given a strange look by my host, who replied that caves make rain, and the smoke of copal nurtures the rains. I was never able to substantiate this statement with other Q'eqchi', nor with any other Maya, but it remains an intriguing communication. Wilson (1995) provides an interesting discussion of cave rituals.

makes it happy. The resinous incense expunges any evil spirits from the maize and the house."

One final example of the function of copal from the Q'eqchi' religious world is the act of fashioning human images from copal. According to Q'eqchi' traditions, when a person unexpectedly falls into a river they lose part of their soul, and are thereby endangered. Serious illness is believed to arise from such a loss, and in order to recover the entity from the river, the person performs a counteracting ritual. The victim's loss is overcome by shaping a miniature version of themselves out of copal, along with bits of hair, fingernail, and even bits of fabric from the person's clothes. The image is taken to the river spot, and is either thrown into the water or buried in the bank. Copal is burned at the same time (Ruth Carlson and Francis Eachus, pers. comm., 1995; see also their 1977 work). In Lanquín I was also told that copal is burned in the homes of the ill, and is considered particularly effective in relieving fevers and coughs. Copal is believed to strengthen and gladden the soul, as well as the benevolent spirits who can aid in curing. Offerings of copal are always present at other events such as house-building, at the onset of journeys, and during important festivals.

In the medicinal realm, several informants described the use of copal as an anti-parasitic agent, for respiratory problems, and as a relief from susto (a cultural disease caused by fear). In the first use, copal *pom* is placed directly onto an area of skin displaying inflammation and signs of parasite activity. I was told, however, that skin parasites do not occur in Lanquín but are found in many of the near low-lying areas where inhabitants often travel to secure work on fincas. By all descriptions, this parasite may be a type of botfly, a common flesh-eating, mammalian pest in tropical areas of Central America. A few traditional remedies practiced in the Maya region are very effective in removal of these pests. For instance, a piece of beef or meat is placed and tied over the affected area and left in order to suffocate the parasites; by blocking the passage by which they obtain oxygen, the parasites are forced to burrow up into the meat to the surface in an attempt to reestablish connection to an oxygenated environment (personal observation). It may be that a layer of resin serves a similar purpose, by forcing the parasites closer to the skin's surface, where they may be more easily removed, or, are in fact, suffocated, and pulled away from the infested area.

One older woman stated that tiny spheres of copal *pom* could be used to fill holes where teeth used to be, or to hold teeth in or together, as a sort of dentrifice. The use of resin for caries is prevalent throughout Central America and in the Americas dates at least to the colonial period (Breedlove and Laughlin 1993:153, 420; Martinéz 1959b:487-489, 1959a:261-265; Monardes I, 1925: 13-15; Standley and Steyermark 1946:427-429). Mastic (from *Pistacia lentiscus*, Anacardiaceae) in the Old World has been used similarly. When the copal is freshly collected, masticated, or heated slightly, the resin easily serves as a plugging material. Some people encountered during field work liked to use copal *pom* as a kind of chewing gum. It is aromatic and said to be soothing.

Wilson (1995:140) reports that *pom* is considered to be "hot" by the Q'eqchi' Maya, and is one of a suite of offerings which share this quality. Among these sacred and "hot" items are candles, beeswax, turkey blood, maize, products, alcoholic drinks, pine torches dipped in blood, and blood itself. Wilson claims that all of these substances are autocthonous, that is indigenous or native, and that Q'eqchi' ritual rarely includes any items derived from Spanish religious paraphernalia.[17] Wilson found

[17] Wilson is mistaken in this statement, however. For instance, distillation of alcohol is an introduced technique, so only fermented beverages would qualify as an indigenous product. Candles are made generally from parafin, a petroleum product, unless they are made from tallow, an animal or vegetable fat. Which native animals or plants used by Prehispanic Maya as tallow sources is

that heat, particularly in the healing of postpartum women and young infants, as well as in the germination of maize seeds, is considered critical to both the nourishment of the gods, saints, and ancestors, and to fertility in agricultural production. I received little information regarding this specific quality of copal *pom* and therefore can only provide the concept as Wilson describes it. The quality of heat is also encountered in Vogt's (1976) work on Zinacanteco ritual, discussed below.

One important landowner in Lanquín stated that only adults or older, especially respectful or wise children were permitted to harvest copal from the trees. Young children were not permitted to participate in collection. Apparently, proper states of mind are prerequisites to copal *pom* collection.[18] I was told by other informants that proper veneration and an understanding of the Maya strictures governing the use of the earth and plants ("the earth's children") is required by the collector. If these qualities are lacking, the collector risks offending the deities and bringing harm upon herself and her family. For this reason, children were rarely permitted to collect copal *pom*, even under supervision, because "their souls are not strong enough." It was said that because children tend to be unaware of the obligate relationship between humans, God and the deities, improper collection could inadvertently bring harm or illness upon

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unknown to the author. Cows, chickens, donkeys, pigs, and horses were introduced by the Spaniards, so these did not serve as tallow sources before the colonial period. An old Tzotzil Maya story, however, suggests that ancient highland Chiapan Maya obtained tallow from sea animals (see below). It is very likely that modern Maya do not produce their own tallow from animals (a time-consuming process) but buy parafin candles in the markets instead. In regard to beeswax, only wax obtained from the native honeybee (*Melapona* spp.) qualifies as indigenous, since all other wax-producing bee species are introduced. Wilson (nor any author encountered in this study) does not indicate the type of bee from which this substance is collected.

[18] An interesting statement by Thompson provides more information on this issue. He states that in the British Honduras [modern-day Belize] fasting is necessary during the collection of the copal, and, before departure, there is required a special drink of ground maize and water which 'bears some resemblance to copal, and by drinking a quantity this it is believed that the yield of copal will be greater'" (Thompson 1939:104, as cited in Tozzer 1941:75, n. 338). He does not indicate whether children collect copal or if they are required to fast as well.

them. An adult who heedlessly injures the copal *pom* tree, which is considered an animate being with a soul, and is, incidentally, an important source of livelihood for many Lanquiñeros, risks soul loss or injury. In a more mundane sense, there is also loss of a revenue-generating natural resource by killing or permanently damaging the tree. In the cosmological realm, that person could invoke the ill-wishes of a vengeance-seeking deity by disregarding the proper process of request and offerings, or gestures of sincere thanks. Especially important is the proper "feeding" ritual performed to counterattack the offense given without proper regard; without this ritual, one might be physically harmed or one's soul lost. Numerous forms of pre-Columbian rules of human-god relationships, while certainly altered and softened in the presence of the Catholic Church and twentieth-century Maya society, are still retained among some of the more religiously conservative Alta Verapaz Q'eqchi'.

In contrast to the western Guatemalan highlands, in the Lanquín area the actual number of "finished" products derived from copal are few. Used primarily as incense, copal *pom* is sold in the crude form in which it will be placed in a brazier or simply lit with a match. When thrown into an incense burner, the copal *pom* ignites with a flash of sparks, sputters, and emits huge clouds of aromatic smoke. As the environments in which I witnessed its use were usually dark, I came to believe that copal *pom* has a strong association with both light and life-sustaining heat (see below), though I was not able to confirm this directly with informants. Wilson (1995) mentions more than one type of *pom* used in the western region of the department of Alta Verapaz (about sixty kilometers away). *Torak'* is the name given to small red pieces of another kind of incense which are burned during certain rituals.[19] *Torak'* is referred to as "pennies,"

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[19] The term *torak'* and the reddish color of the resin, described by the author, closely resembles a resin I encountered in the western highlands of Guatemala. This is *estoraque*, which I believe may originate from *Liquidambar styraciflua* (Hamamelidaceae). Another resin type was located by David Goldstein (pers. comm., 1999) called *oraqi*, but I lack a description of the color and nature of this

(see Ch'ortí discussion below) and a specific number, thirteen, sixteen, or eighteen, are burned. Wilson's explanation for the different types of copal *pom* is based upon the Q'eqchi' concept that as humans require diversity in their diet, so do the dieties and saints. Thus offerings made in caves must reflect and meet such needs. In a prayer recorded by Wilson (1995:72), the petitioner names green *pom* and white *pom* (presumably copal from *Protium*, based upon the author's statements). I was never told of another kind of *pom* in Lanquín, but it is possible that this omission or difference stems from cultural variations between geographically separate Q'eqchi' within the department.

Copal and the Q'eqchi': a brief summary

Clearly resin collection is important to the Maya inhabitants of Lanquín, Alta Verapaz. Processing techniques are simple and yields appear to be high. The data collected during the fieldwork period and presented here is the only documentation of its kind and no comparable data were located in any of the literature. Copal *pom* is an item of great importance in traditional Q'eqchi' Maya ritual and is perceived to possess medicinal properties as well. The above discussion is groundwork which will permit other, more esoteric, concepts with which copal is associated, to be introduced.

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resin. It is possible that *torak'* and *oraqi* are derived from or share a common origin with the term *estoraque*. One author (Aguilar Girón 1966) attributes the common names *estoraque brujo* and *estoraque de montaña*, however, to species of *Styrax argenteus* and *S. volcanicola* (Styracaceae, Aguilar Girón 1966. 190), and then *incienso estoraque* as *Bursera bipinnata* (Aguilar Girón 1966:180). At the very least, this demonstrates the confusing nature of relying on common names in botanical research. As stated before, *Liquidambar* is likely to be an important source of resins in the department of Alta Verapaz, but its use has not yet been observed by the author.

Questions about resin revenues, income value to rural and town-dwelling Q'eqchi', which were introduced above, could also form the basis of further studies. Coordinated ecological studies of the forest communities of copal-cacao in Lanquín could yield interesting data regarding accurate counting of individual *Protium copal* trees, potential size or age classes of trees, and regeneration rates and dynamics in these tended groves. The copal tree was seen to be ubiquitous in the neighborhood of Lanquín; there could easily be thousands of tree within the town perimeter. A comparative study investigating the floristic region surrounding Lanquín, including the steep mountain tops nearby, might demonstrate areas of main copal-tree sources and their relation to other land uses, and perhaps, contribute evidence regarding possible anthropogenic influence on the flora in regional scale.

The K'iche' Maya of the Department of Totonicopán, Guatemala

Introduction to supplementary field research in Totonicopán

There are several language and cultural regions in western Guatemala, based upon geographical, cultural, political, and linguistic characteristics, and which often cross departmental boundaries. These regions are characterized by distinct differences in language, traditional clothing (by which many Maya ethnicities distinguish themselves), historical development and events, and degree of retention of traditional ritual practices. Some differences in agricultural crops are also present in some areas. The Kakchikel region was initially chosen as a general area in which to begin studies of plant resins among indigenous Guatemalan Maya (Fig. 47). An opportunity to learn the Kakchikel language provided a means of introduction to an important Maya language and culture, and a means by which informal interviewing could commence and plant resin producers and users located for further studies. By the end of the three month course I determined that although a range of resins could be found in the different markets of the Kakchikel region overall, especially in the larger market of Antigua (the former colonial capitol of the country), the frequency of copal collection and use was less than that in the K'iche' region. Very few of the copal vendors could or would say where their supplies originated, in comparison to more remote places I traveled to in the company of my Kakchikel teacher, Ronal Simón. By all accounts, the K'iche' region, north and northwest of the Kakchikel area, was a major source for many of the resins encountered in the markets.

Only one official interview with a copal processor was obtained among the K'iche' Maya. Locating this stratum of Maya occupation was very difficult. The investigative trail began in Totonicopán (see Fig. 52), where several market vendors were questioned regarding copal products, sources, uses and prices, but little hard data could be collected. A rapid reconnaissance of the copal vendors in the market in Totonicopán yielded little information regarding taxonomic or commercial sources. One town, however, Santa María Chiquimula, immediately south of Momostenango, was finally given as a source of copal and another informant confirmed that Santa María Chiquimula was, indeed, an important source of pine resins and suggested going there. After determining that buses were the main means of travel to the town, the informant agreed to serve as a guide and translator if necessary. A fee was agreed upon and a time and location set for an early morning departure to Santa María Chiquimula. Unfortunately, the man failed to arrive the next morning. It was decided that the town of Chiquimula would be reserved as an interview site for the future.[20]

[20] It was later discovered in McBryde's study of southwestern Guatemala (1948:74), that Santa María Chiquimula specializes in the collection and processing of resin exudates for incense, presumably

Because of time constraints, a decision was made to move onto the next large K'iche' town of Momostenango, where both market interviews could be conducted and producers sought (described below). A final brief visit to Chichicastenango and the famous church of Santo Tomás, a destination for many Maya pilgrims (and tourists), appeared to confirm the observed trend that plant resins appear to be more important to the everyday life of contemporary Maya in the K'iche' ethnic region than to the Kakchikel. In fact, foreign travelers often make a determined effort to visit Chichicastenango because it is a "picture post-card perfect" sight when the church steps are full of copal smoke and colorful flowers and traditional clothing, and rituals or fiestas are occurring. Such vivid manifestations of Maya religious practices are lacking in most Kakchikel towns and helps to explain Chichicastenango's popularity with tourists.

In contrast to Lanquín, where only one resin type was found growing and traded commercially, numerous resin and copal types were found for sale throughout the western highlands, especially in the K'iche'-speaking area (see Table 1.3). For instance, one copal type, copal amarillo, is highly esteemed as incense. I found it frequently in both Antigua (Department of Saquetepéquez), Totonicopán (Department of Totonicopán) and Santiago Atitlán (Department of Sololá). It was not always called copal amarillo, but simply copal. This type is the preferred and most frequently used copal incense by the cofradías (fraternities) in Santiago Atitlán (Sololá, Allen Christenson, pers. comm., 1998), and was seen only once outside of the region, in Chiquimula (close to Honduras); it seems fairly restricted to the western highlands of Guatemala. The resin appears to be heated and cooled, because it is very hard and clear, dried to the transparency of glass, and generally comes in large cakes which

from *Pinus teocote*, and supplies the Quetzaltenango, Totonicopán, San Francisco El Alto, and Sacapulas markets.

sometimes have rounded edges (e.g., Fig. 64a). Once broken the resin breaks into small pieces, it fractures in a very brittle manner to the consistency of a very fine powder. It is very bitter tasting, and when burned, creates copious quantities of white smoke. Heating the resins as part of preparation techniques, be it as incense or as medicine, or as caulking material, is known for certain for only a few resins observed in this project. Other resins encountered in the highland markets are given in Table 3. Unfortunately, most could not be identified to species based on color and form.

I arrived in Momostenango's large market, during a feria (fiesta), in the first week of August, and encountered many resins similar in type and use to those found in the market at Totonicopán. Again, inquiries were made among market vendors, for resin products and copalleros. Copal negro appeared to be more prevalent than other types and we were told that the logs of copal, or *tiras*, were made nearby. We encountered a woman vendor, a K'iche' speaker, with the most numerous resin types for sale yet seen, and she informed us that a man from a small village three or four leagues away "made" copal and sold it in Momostenango from time to time. He was the only one she'd heard of in the area, although she said that there was an aldea (a small, outlying community) some distance away where the inhabitants were known for copal collection, due to the abundant resin-producing trees there.

We pursued the vendor's lead and one copallero was finally located in the aldea of Canquixajá, approximately ten to twelve miles northeast of Momostenango (and still part of the K'iche'-speaking region). The man, Pablo Vincente, appeared to be in his mid-twenties, with a moderate-sized, sloping milpa in cultivation around his modest dwelling. After agreeing to an interview, he told us he was recently married and did not have children. That he "made" copal negro when he "found" pine resin, or "trementina" (*Pinus* spp.). Mr. Vincente informed us that although he lacked the materials, he would give us a demonstration and explain the process he used to make copal negro.

Taxonomic identity of copal sources, collecting season, and processing methods in Canquixajá

Vincente stated that he did not collect the pine resin himself but in fact purchased it when he had enough capital; at which time he would travel to Pank'ay or Xepom, the latter an aldea he said was only an hour and one-half away, walking. (We'd heard elsewhere in the market and at one of the tiendas, that Xepom was located four hours away by foot from Canquixajá. Also, note the inclusion of the term *pom* in the town's name; which may or may not be deliberate). There "the people have many pine trees and they work with resins and making copal. Vincente could not tell me whether the trees in Xepom are owned individually or communally. When asked how he obtained the resin he said, "People just come in trucks and sometimes I just stop the truck and buy trementina from them." So, apparently the traffic in resins from Xepom is high. "...In Xepom, making copal is their only business" (I was not able to confirm this statement at the time but would like to visit this aldea in the future).[21] In regard to trementina collection, Mr. Vincente stated that the collectors "make a little hole in the tree or they chop part of the tree [off]. From the hole the trementina falls down and they just pick it up." "It takes so long to fill a *tinaja* [a plastic water jar of variable size; the most common *tinaja* holds slightly less than one gallon in volume measurement]. Like now, when it's raining, they just don't collect it [because it is cold and wet outside]. So when it's not raining people go and collect

[21] Xepom has been located on a map and is located about 20 kilometers north of Momostenango, as the crow flies (Healey 1991).

trementina. They can collect a few *tinajas* of trementina." According to Mr. Vincente, one jar of trementina makes "about two and a half dozen" copal units and costs about forty five quetzales (this is in the rainy season, and may well vary in price throughout the year, especially in the dry season), or about nine dollars in U.S. currency. Mr. Vincente informed us that he would usually purchase one *tinaja* of trementina at one time, when cash was available.

The copal product Vincente described was composed primarily of pine resins and material from oak (*Quercus* spp.). There is still some question as to whether only the bark of the tree and the leaves or both were used during processing, because Vincente was occasionally confused when describing the ingredients in his copal. He initially specified that there were only two ingredients, resin and oak bark "which must be minced until fine and mixed with boiled trementina." He instructed that the composite mixture must be sticky, therefore the amount of oak should be monitored; too much bark causes the resulting mixture to lose it's stickiness. The resin to bark ratio was not given. Mr. Vincente calculated the need by sight and experience. The resulting mixture must be sticky enough to be able to be placed into a mold and hold that shape as well. According to Vincente, the resin must be boiled approximately fifteen minutes, either in a ceramic (olla) or a metal pot (an expensive commodity). The amount of copal made is determined by the speed with which the processor works. "When you don't work fast you make just a little bit." Apparently the material must be worked quickly, otherwise the resin becomes hard as it cools, and can no longer be worked. When asked if someone told him how much bark to use, he replied that no, he had figured it out himself. He stressed that if too much bark were introduced into the mixture that he'd lose his investment of forty five quetzales. When asked if other bark or leaf types could be substituted for the encina, Vincente replied no, only leaves of encina, but perhaps he meant bark, instead. A close look at his copal negro shows small bit of organic matter that could be finely ground leaves.

The mold into which the bark (or leaf) and resin mix is pressed is simple, made of an unidentified wood (probably pine). The mix is mashed into the mold, pressed, and then tapped out onto the floor to dry. The product resembles a small hockey puck of composite material, dark brown and about four to five centimeters across and one to two centimeters tall, with a slightly depressed center (Fig. 64b). Mr. Vincente pointed out that the pieces melt easily in the sun, and therefore are dried and stored in the shade. When enough pieces are made, they are assembled into logs or *tiras*, each consisting of about seventeen pieces wrapped in a banana leaf. Mr. Vincente stated that one *tinaja* resulted in two and a half dozen *tiras*. The final product, the *tira*, resembles a small log in shape and size, and is called copal negro (Fig. 67). These units can be sold whole or sold as single small units (considerably smaller, cigar-sized, logs of copal negro were located in the Momostenango market, as well as individual pieces of copal negro sold separately).

Vincente purchased banana leaves by the *carga*, about thirty leaves, a large number in contrast to the smaller traditional market unit of twelve leaves. He said that after the bananas are harvested that the leaves, too, can be cut and dried. He had to purchase numerous leaves because his milpa did not yet possess enough banana plants. His approximate cost for the banana leaves was twenty five to thirty quetzales.

When asked if he sold a lot of the resin mixture he stated, yes, "about five, ten or fifteen dozen [at one time]. Because it takes too much work to make it. When one has family they can help and when you have a lot of trees you can make a lot of resin. Like this coming Sunday I will take some to Momostenango. Probably ten dozen [large logs or *tiras*]." Vincente estimated that he made twenty dozen *tiras* per year, explaining that he spent part of the year working on the coast and the rest of the year working his milpa. When asked how much he received for a dozen logs of copal negro, or *tiras*, he gave no reply. Later it was resolved that he sold each *tira* for one and a half quetzales in the Momostenango market to travelling merchants.

Certain elements of Mr. Vincente's production of copal negro can be put into monetary terms, other elements cannot. For example, for one unit of trementina (pine resin), the *tinaja*, Vincente reportedly paid forty five quetzales. This investment price may fluctuate throughout the year, in response to degree and intensity of collection, seasonal output of resin-secreting trees, and so forth. Vincente's purchase of a *carga* of banana leaves, with which to wrap his product, added an additional significant cost. This results in an outlay of seventy quetzales for an estimated two and a half dozen logs of copal negro. Although Mr. Vincente informed us that he received one and a half quetzales for one *tira*, we could not determine if he ever sold his product in bulk for a discount and smaller price. If one calculates the number of *tiras* produced from one *tinaja* by Vincente (30 pieces) multiplied by 1.50Q, we arrive at a total sum of 45Q received for all of the product. These calculations must be in error, however. Vincente stated that "I make 15Q profit on one *tinaja*. I buy the banana leaves....I make enough to buy an *arroba* (about 10 kgs) of maize for *masa* (flour) and some salt." The only way Mr. Vincente could reap a profit of fifteen quetzales is by charging 2Q per tira (45Q (cost) plus 15Q (profit) equals 60Q, divided by 30 pieces, equals 2Q). This does not even include the cost of the wrapping material. Time investment is not included in this calculation, either. The time, for instance, that it takes Mr. Vincente to walk to an aldea where trementina is sold, and the return trip home, collection of bark and/or leaves to amend the resin, and processing time (boiling, molding, and packaging) are not translated into hourly currency worth.

I asked Mr. Vincente if others in the area processed trementina into copal negro. "They don't produce very much because it is not the business of the people here. It's just when I don't have anything else to do that I make copal," and repeated the information regarding migratory work. "Here I just make copal in my free time. I own this much land (points around him). I work on the coast. In Xepom, making copal is their only business." When asked where and to whom he sold his copal negro, Vincente replied that he went to Momostenango (walking, most likely, about twelve miles away) and sold them "to merchants who take them to the city [the capital, Guatemala City] or to Xela [Quetzaltenango]." I specified that therefore he sold none of the copal in the market and he responded that he never saw his copal in the market at Momostenango.

When asked who taught him to make copal, Mr. Vincente said, "I didn't learn it from anyone. Last year when I went to the coast to work, I met this man from Xepom who told me that in my free time I should make copal. This man gave me a mold and explained to me how to make copal. So then I decided to make it because I needed to make some money."

Mr. Vincente provided just a few remarks about the function of copal in K'iche' society. He was asked if he knew the source of the resins used as throat medicines, or was familiar with any other types of resins. Mr. Vincente replied, no, in regard to the former question, and verified that the trementina he purchased to make copal negro was not the same as the cough medicine purchased earlier in Totonicopán. Mr. Vincente, however, did not seem very familiar with resin types other than that with which he worked. It is possible, as well, that he was not Catholic, since Protestantism and other religions have a widespread and growing presence in some

Maya communities. In that case, Vincente may not have been afforded much exposure to the ritual uses of copal.

Mr. Vincente then pointed out an important feature of the copal negro, it's color, and offered an explanation: "It's blackened because people collect from the trees that are burned. The resin is [charred] black because of the smoke." This was a curious addition to the interview and its significance is not clear. Nowhere in the conversation did the issue of burned trees arise before this point. I have not encountered personally tree-burning as an inducement to resin secretion. It is possible that the sites in which the pines grow endure natural fires on a regular or periodic basis, thereby producing blackened resin secretions. I do not know the original color of the trementina resin prior to boiling (pine resin has range of colors when first issuing from wounded tissue, and may become white upon exposure to air), and certainly the process of boiling and the addition of organic matter could cause a change in color. Trees that have burned would not necessarily secrete blackened resin, and certainly the collection of charred carbon (from the bark) along with resin could color the material. My Maya companion noted that in 1982 the Guatemalan Army burned a great deal of mountain habitat in this region in an effort to destroy guerrilla strongholds and that perhaps this is the burning Mr. Vincente referred to, or perhaps, to the frequent brush fires of the dry season. All copal negro encountered by myself in Guatemala was black and composed of a mixture, however. I find Mr. Vincente's explanation of the black color intriguing. The interview was concluded at this point.

One other K'iché informant to whom I spoke stated that he used pine resin to seal skin wounds and splits in his feet. He described how if he received machete or knife wounds he would clean the cut with water and then put a layer of soft, fresh pine resin on it. He applied soft resin to large splits in the sole of his feet (many Maya do not wear shoes or wear only sandals, by which they receive a great deal of exposure to the weather and other elements), a practice shared by Tzotzil Maya of Larraínzar, in Chiapas, Mexico (Breedlove and Laughlin 1993)

Copal and the K'iche' Maya: a brief summary

Numerous copals and other plant resins are sold in the Western highlands (detailed images of different exudates purchased in markets are given in Figs. 67-75, also see Appendix 2), indicating several taxonomic sources, especially the pines. A second method of copal processing, involving a purchase of resin from a source some distance away, and several steps, was located, and contrasts strongly with resin processing in Lanquín, Alta Verapaz. Instead of one resin source being used for a number of purposes, in the highlands there are specific resins for illness and others used specifically as incense. Unfortunately, data regarding the economy of copal collection and processing are weak and not very informative. There exists a more complex structure of economy than that of Lanquín, as evidenced by Vincente's statement that there is an aldea where the inhabitants specialize in the collectin of pine resins. I will return to the K'iche' again below, but to an earlier period, the Colonial Spanish period, and discuss some evidence regarding copal's significance in K'iche' Maya cosmology.

The Ch'ortí Maya of the Department of Chiquimula

Taxonomic identity of copal source trees and processing methods

The Ch'ortí Maya live in southeastern Guatemala, adjacent to the Honduran border. Copal is reported to be collected in this area from a species of *Bursera* and is considered one of the most sacred substances by the Ch'ortí (Wisdom 1940:387, 474). Wisdom provides a succinct description of collection and processing methods. The men of the community locate trees in the hills, make incisions in about a dozen places on a single tree, all on the same side, place a gourd below, and let the tree alone for eight days. The exudate, along with a lot of bark (which they apparently collect at the same time), is set in the sun for a day, and then both the bark and the resin are boiled in water. As the water evaporates, new water is added. As the exudate rises to the top, it is skimmed off, until all is extracted, about eight to ten hours, after which it is placed into cold water to harden. Wisdom does not specify whether the material skimmed off the boiling water includes bark or the resin alone. The boiled product is then molded into "round, elongated pellets, each about the size and shape of a cigar, and extremely hard and brittle. For ceremonial use, the gum is shaped into small disks" (Wisdom 1940: 387, 474). Only one sample of incense, called copal negro, purchased in Chiquimula (Figs. 7a, b), resembles this description. The product is shaped quite like a cigar. The second sample, copal blanco, is odd in that it is composed of rectangular chunks of what appears to be sawdust, coated in a layer of white material that resembles cake icing. Both are wrapped in maize husks. A sample of copal resembling the yellow translucent types found in the western highland markets was also purchased.

Pines are used in the area, though only as torches, as is found throughout Mexico and Mesoamerica. Wisdom indicates that *Pinus oocarpa* is the primary source of the resinous wood. He relates that the central portion of the trunk is cut into two-foot long pieces, and further split into strips of about an inch thick and two inches wide. These torches are used to accompany travelers on the trails at night, for lighting houses, and for transferring fire from one house to another. A good supply of these torches is always on hand. IR analysis (Ch. III), however, suggests that *Pinus caribaea* var. *hondurensis* (=*P. caribaea*) may be the source of copal negro resin products in the Ch'ortí region.

Resins in religious ceremonies, everyday life, and medicinal treatments

Wisdom (1940:182-183) notes that during ceremonies and rituals, copal disks are burned. Each is the size and shape of a small coin, and is called a "peso," in which form it is treated as ceremonial money and "is sacrificed to the deities" and offered as payment by burning in incensarios. No other information on collection or cultivation is given, nor was this form of copal seen by the author. The use of copal pesos in the 1930s and '40s seems to demonstrate that the Ch'ortí conflated the value of government-backed currency with that of copal pesos. A curious, but practical, domestic use of resin is also described by Wisdom (1940:37, and n. 21, see also 387, n. 36, for copal as possible currency in past). The Ch'ortí used real silver pesos in the 1930s and earlier as currency, and also as amulets to ward off illness and sorcery. When paper currency was introduced, many pesos turned into the bank were pierced for this purpose, but were plugged with copal to make them appear whole, since damaged pesos could not be accepted.

One example of "payment" with copal is that made by hunters. Prior to hunting, the number of pesos required to propitiate the deer god are sent to the hunter in a dream, who "pays" for the animal by burning copal pesos. If this is not done, the deer are believed to leave the vicinity. During the hunt, while the men are away, the women at home burn copal constantly and pray to the family saints for a successful hunt. If the men are triumphant, they alert the women from some distance. Copal is lighted immediately and the carcass censed with the fumes to purify the meat and to drive away evil spirits from the body (Wisdom 1940:72-73).

Copal pesos are explicitly offered as sacrifices in ceremonies. Sacrifices consist of only the most sacred objects, especially maize, turkeys, and copal, which are sometimes sacrificed together. Copal is formed into small ears of maize or into pesos and buried whole or burned on family altars. Although one receives the impression that the Maya in general are respectfully fearful of the gods and saints, their relationship often seems business-like, as demonstrated by the Ch'ortí , who tell the deity "that such and such a payment is being made to him, in return for which he is expected to send what is asked." This statement is somewhat reminiscent of the social relationship between the petitioner and the deities recorded by Wilson (1995:75) for the Q'eqchi'. Wisdom even notes that some rivalry exists in terms of amount and timing of payment: "It is said that, if others make a greater and earlier payment, they will receive the favors of the deities, and so it is sometimes stated in the prayers that the payment being made is both the first and the best that anyone could make and should therefore receive first attention" (Wisdom 1940:435-436, and n. 6).

Of all of the Maya ceremonies, the calling of the rains, planting and harvest are the most important. The planting ceremony resembles the rain ceremony closely, and I describe only the former here. The Ch'ortí farmer initiates his planting ceremony at the beginning of the rainy season, by stating, "I am going to pay the earth [gods]." He provides turkey blood to the four corners of the milpa. He then digs a small hole in the center of the milpa and throws in a large amount of unsweetened maize gruel. The blood of the fowls and the gruel are said to protect the milpa from animals. More interesting, however, is that just to the north of the center hole, he creates another, fills it with more gruel, then places yet another hole south of the center offering, and fills it with a package of copal pesos. The gruel (*chilate*) "is called the companion of the copal, which relation may indicate their connection with the idea of fertility, and therefore symbolizes the dual-sexed earth deities to whom the ceremony is directed. It is believed that the maize plants are born of the union of the two-sexed pair. He then consecrates the seed in the fumes of copal smoke, burning about one hundred pesos" (Wisdom 1940:442-443, and n. 15). In November, the harvest storage ceremony is enacted to protect the harvest. Copal is molded into the size and appearance of four ears of maize, given personal names (of saints), and wrapped in cloth. Prayers are addressed to each entity as the maize images (mazorcas) are placed at the four corners of the crib.

To supplement their diet, when the maize supplies of the previous year are low, and the first maize harvest is not yet ready, the Ch'ortí rely on numerous edible greens, including the fresh shoots and leaves of *palo jiote* (*Bursera simaruba*) in the months of May and June (Wisdom 1940:84). The boughs and trunks of the same species are the only ones used as the vertical axis of the crosses found in the family compound and throughout the community, especially at the roads leading into the settlement. The wood is said to be cut and planted only on May 3, the official start of the rainy season. These crosses can be literally "living", as some continue to sprout and grow where they are set. The crosses are believed to repel black magic, evil spirits and to deter their mischief. Wisdom (1940:420-425).reports that they seem to be thought of as deities, not just as protective objects and symbols.

As appears common in Maya medical tradition, the Ch'ortí believe that much of the efficacy of a remedy is due to its likeness to, or association with, a sacred person or object. Remedy material is perceived to resemble parts of the human body, to be the means by which illness affects the body, the source of the illness, or the conditions caused by the illness itself. Wisdom (1940:364) suggests that copal and rue (*Ruta graveolens*, Rutaceae), are medicinal because of the "pungency" of their odor, especially when cleansing the body of "nonnatural *aigres* (winds, disease)," which can be brought on especially by magic or supernatural mischief or anger. He also states that plants "which are merely pleasant, like most flowers, are not often used medicinally," although they are frequently a part of ritual adornment. Ch'ortí curers use copal in one of five medicinal treatments, and sometimes all five if the case is very serious.

For example, copal is considered to be an extremely powerful remedy for cleansing the body (Wisdom 1940:346-351, and n. 16). The patient is "incensed" in the smoke for a few minutes, as are all the rest of his or her clothes. The perceived action of the smoke is similar to that of "spitting," in which tobacco (and sometimes other, aromatic, plants) is chewed and then spat upon the naked body of the patient (sometimes in the form of the cross). Copal is particularly effective in fending off future illnesses, accidents and misfortunes, by protecting people, plants, and animals from sorcery, *aigres*, evil eye, strong blood, and corpses. The result of "incensing" is somewhat likened to "seizing," in which a ritual object, tobacco, turkey eggs, or artemisia leaves, are offered to the illness as a "better" abode than the human body. With the help of the saint and the medical practitioner (curandero), the objects "seize" the illness from the patient's body, and shift it to themselves. Wisdom rightly points out that in this situation, the curative objects are "passive," and although presented as an offering to the diseases, they are not meant as food or propitiation, but as a substitute for the human body. Once the transfer takes place, the new dwelling is destroyed and buried, along with the illness. Wisdom refers to a treatment in the Yucatán called *santiguar*, in which "pure" healing objects are placed on the body "to coerce sickness out of it."

The explicit use of copal in Maya magic was rarely encountered elsewhere in the literature, but among the Ch'ortí , when used magically, copal fumes are thought to be favorable because they usually ascend. If copal smoke descends, the copal should be thrown away, as it has been enchanted by a sorcerer. The concept of ascension or up is considered good, while that of descent or down, is evil (Wisdom 1940:427). As in most Maya societies, the Ch'ortí believe that in the upper layers of the earth live the benevolent deities and saints, while in the dark, cold recesses of the earth, live malevolent beings.

Copal and the Ch'ortí': a brief summary

In the past, the Ch'ortí have fashioned resin into "pesos," and treated copal as a substitute for money. The concept of "payment" is clearly prevalent among the Ch'ortí, especially in their vivid agricultural rituals. Only one taxon is indicated as a source of copal by Wisdom, but recent field work supports collection from at least one pinaceous source at least.

The Tzotzil Maya in the state of Chiapas, Mexico

In this section I conflate three distinct, but geographically close, Tzotzil Maya groups, of Chiapas, Mexico, into one discussion. Although the three groups I consider here, the Chamula, Larraínzar, and Zinacantán Maya, are often treated individually in ethnographic and botanical studies, and are distinct from each other in many ways, I will take advantage of their geographic proximity to draw the reader's attention to them, especially as they provide additional insight into the use of plant resins as copal and as medicine (Fig. 47).

Taxonomic identity of copal source trees in the Tzotzil region

The Flowering of Man: A Tzotzil Botany of Zinacantán (Breedlove and Laughlin 1993) presents the first encounter with specific medicinal methodology and a number of taxonomically identified sources of copal. Although copal *pom* is a term used in their work, because, presumably, that is a term commonly used by the Tzotzil, Breedlove and Laughlin do not define the term. I therefore think that it refers to any type of *pom* used as incense. *Pom* is classified by the Tzotzils as "hot." The authors state that the resin can be used as incense, but interestingly, all but one of the prescribed medicinal uses rely instead on splinters of wood from the aromatic trunk wood, known as *ocote*. *Ocote* is an important highland market commodity, composed of highly resinous pine wood, cut into splints, and sold in bundles in the highland markets.

The number of splinters is apparently measured out carefully and these are often combined with other plants or materials, presumably to increase the efficacy or to enhance the activities of one or both substances. One exception to the use of splinters is the "hot" resin of an unspecified species of *Bursera* employed to plug dental caries (one application a day for three days). Breedlove and Laughlin relate that in Tzotzil speech, the term "*pom* (-tik)" is a set of generic terms which refer to two specific *Bursera* species. All are thick-trunked trees or shrubs with resinous sap that can be made into incense. Occasionally, the different kinds of *pom* resins are mixed together and may also be mixed with "pit" sap (guanacaste, or *Enterolobium cyclocarpum*, Fabaceae;[22] Breedlove and Laughlin 1993:115, 179).

The first type of pom, mud *pom* (*ach'el pom," or tzo'ka' pom*) is collected from *Bursera bipinnata*, described as shrubs or trees to 10 meters in height. Mud *pom* trees are planted in a few of the temperate, high-elevation communities of the Tzotzil region. The trunk and wood are the source of most listed uses. For instance, the trunk is used as firewood and as incense, but is reportedly less fragrant than "genuine" pom. A hot tea, composed of thirteen splinters of *Bursera bipinnata* together with thirteen splinters of "*tzajal tulan*" (*Quercus rugosa*, Fagaceae; Breedlove and Laughlin 1993:188), is drunk before breakfast for a loose tooth.

"Genuine pom" (*batz'i pom*, *muk'ta pom*, or *pom ryox*),[23] from *Bursera excelsa*, is planted as a fencerow tree (again in many of the temperate, high-elevation communities of the Zinacantán region) according to the authors, and the trunk is used for incense, but here again the wood appears to be used, rather than the resin itself. Three or six "hot" splinters are the basic ingredient of "flower water" (*nichim*), prepared with numerous aromatic plants and water from sacred waterholes; they are boiled and used to bathe patients, newborns, occupants of a new house, sacrificial chickens, and stewards' coffers. No specific collection data is given but it is likely that

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[22] The sap of this tree is considered "hot" and is used as a hot beverage for the treatment of whooping cough (Breedlove and Laughlin 1993:171).

[23] *Batz'i* indicates "genuine," *muk'ta* refers to resin and chips sold by the inhabitants of Muk'ta Jok', and the term *ryox* may share the same definition found in some other Maya languages, namely "red."

entire trees or, perhaps, branches, are cut down for supplies. Slivers approximately fifteen centimeters in length are chopped again into smaller chips. Specific numbers of these chips are given to the different office-holders in the communities. For example, "an ensign-bearer entering office presents six chips to the corresponding musician. The cantors and judge ordinarily give three apiece to the musicians and [revered elder]. An elder, when entering office, should have six burlap bagsful of incense. The elder's wife burns the incense three times daily. Stewards and stewards-royal need eight bagsful. One basket is required by the offical in charge of each Holy Cross Day ceremony. One basket is needed for a curing ceremony" (Breedlove and Laughlin 1993:179). The sizes of the bag and the basket are not given.[24] In addition to its ceremonial application, "genuine *pom*" is also medicinally used to reduce swelling (Breedlove and Laughlin 1993:179).

The final type of *pom*, "horse *pom*," (*Bursera steyermarkii*), is also a source of medicinal remedies. A tea of bark and wood chips, brewed with brown salt, is used to relieve heartburn. A "hot" tea of six or thirteen splinters is used to combat "wind," and the leaves are used for a "steam cure." Steam cures, *pus ton*, are used to reduce swellings, and are also prescribed following bloodletting. Thirteen brown river pebbles are heated until red hot. On top of these are placed a variety of plants over which is poured a large gourd of the assistants' urine (Breedlove and Laughlin 1993:446). The authors identify the habitat of "horse pom" as limestone outcrops in tropical deciduous forest in the lowlands (Breedlove and Laughlin 1993:179). Information regarding degree of cultivation or management of resin-producing trees anywhere in Chiapas is extremely hard to obtain, but according to the suffix "-tik," appended to the term pom, the species apparently grows in large expanses.

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[24] In Ch. III I discussed the use of aromatic wood chips available in the Quiché region (*mirra* and *ocote*).

Breedlove and Laughlin (1993:179) include a modern story told about copal *pom* by a Tzotzil informant[25]

> Long ago when people saw the incense tree they did not know what it was. They thought it was a useless tree that hardly grew. Our Lord told them, "It will grow tall. It will have fruit." He cut a strip of bark off. "Come, look in three days!" he said.They came back to look and then they saw the resin. Our Lord took it. "This is the tree's smoke," he said. "It is very fragrant. Use it with flowers in your curing ceremonies!" he said. Our Lord gave them a censer and an ember. "This is how you cense the patient, this is how you cense the clothes," he said.Then he told them, "There are two kinds, genuine incense and mud incense, but mud incense is not as good."

As Breedlove and Laughlin point out, the "*pom*" set is restricted to and descriptive of members of the Burseraceae. Once we venture away from this linguistic set and its associated plant taxa, we find, indeed, that there are more resins in use as incense than at first appeared. Their perceived quality, especially as ritual incense, is considerably less than that of *pom*, but their use as medicines renders them significant, nonetheless. For example, the Zinacantecan linguistic set "*toj*" contains only conifers and is the only set to do so, consisting mostly of *Pinus* species (seven) (other sets usually contain more two or more, somtimes unrelated, genera). Breedlove and Laughlin state that this set includes all of the coniferous trees that occur within the

[25] Note also, that use of the term *pom* is resumed, and is specifically applied to the Burseraceae. As noted previously, *copalli* is a generic Nahuatl term, presumably applied to all incense, whether used in ritual or medicinal treatments. As one moves south, away from the Valley of Mexico, one finds the compound term, copal *pom*, in use among the Tzotzils, rarely among the Kiché, and commonly used by the Q'eqchi', and other Maya groups living northward toward the Péten and Yucatán, an interesting geographic distribution.

township (Breedlove and Laughlin:182). "*Toj*" is the generic term for pines, and according to the authors, the taxonomic groupings within the set are complex, based upon four primary morphological characters: bark color, bark thickness, foliage density, and cone size. Resinous wood slivers, and occasionally resin, are utilized. *Pinus michoacana* and *P. oaxacana* have ceremonial applications and *P. oocarpa, P. teocote, P. montezumae* var. *rudis,* and *P. ayacahuite* all possess medicinal properties in the experience of the Tzotzil, primarily for dental problems and as antidotes to spider bites (Breedlove and Laughlin 1993:184). While the branches of *Juniperus* spp. (*ok'il te'*, coyote tree, -tik), are occasionally used by Ladinos as incense, they rely primarily on the branches, which are used to decorate crèches, grave decorations on All Souls' Day, and doors and crosses of the Chapel of Our Lord of Esquipulas.

It is interesting to consider some unspoken aspects of Maya ritual plant use in regard to pine branches and needles, prevalent in nearly all ceremonies. The branches and trunk contain numerous resin canals or pockets in which are stored terpenoids, hence their aroma and medicinal properties (see Chapter III). For all constructive purposes, this internal packaging of aromatic material may be considered a "gentler" form of copal by the Maya, although it is not stated so in any of the literature encountered, nor in my interviews. In Antigua, Guatemala, especially during Semana Santa, elegantly constructed alfombres, or rugs, are constructed in the cobblestone streets. They are composed of flower petals, pine needles, grains, and dyes. The holy procession, replicating Christ's carrying of the cross to Calvary, travels over the sacred alfombres, releasing the heavy scent of pine, while clouds of copal smoke billow everywhere. In most cave ceremonies or altars I witnessed there was always at least one pine branch, accompanied by showy flowers, candles, copal incense, and alcohol.

Tzotzil terms used in regard to resin and resins are a significant subcategory of nomenclature related to stems and trunks. The phrases used to describe resins and saps characterize these exudates as one would human exudates, such as pus, blood, milk. The terms are given here, followed by specific plant taxa cited as examples from the Tzotzil flora (Breedlove and Laughlin 1993:450). Note that there are no members of the Burseraceae present. It is not known why this is so. Also, the majority of these exudates are technically latexes, in contrast to those from pine, whose exudate is an oleoresin by definition, so what application Tzotzil terms have to true resins remains unknown.

Resins in religious ceremonies, everyday life, and medicinal treatments

The Tzotzil Maya of Larraínzar, Chiapas, Mexico, in common with other Maya groups discussed here, share convictions regarding debt-payment and feeding of the gods. According to Holland (1989),

> there are various incenses used by the inhabitants of Larraínzar, but he did not indicate any by name.They believe that, as they are inherently sinners, they should consume the food that the gods have given to them, and in return for their benevolence, propitiate the gods. If the offerings are not adequate, the gods become enraged, sending illness to remind the Tzotzils of their social and religious duties. Tzotzil legends tell of frequent cases where the patron saints of the community, instead of attending fiestas in their honor, gladly abandon the pueblo and depart for another, where they will be appreciated. For this reason many Maya take great care to remember their daily devotions, accompanied by candles and copal. According to Tzotzil belief, the gods do not ingest food like humans do, but are pacified and nourished with offerings

of copal, aguardiente, candles, and fireworks....the incense and alcoholic [fermented] drinks fulfill the same function as *balché* among the ancient Maya of the Yucatán and both are indispensable preliminaries to all petitions to the gods by individuals or groups. Some of [the offerings], if not all, form part of each ritual, whether in a private curing ceremony, in the church, on the sacred mountain....The gods are immortal, perfect, and transcendent because they do not eat human food (Holland 1989):74, 86,123, my translation).

So far, I have not really considered the role of language as a transforming event and process. I have explored nonverbal symbolism and gestures which are *based* on an oral tradition, rather than the language itself, which accompanies ritual ceremony and process. I would like to add to the discussion, however, a very brief mention of one modern form of ritual language, one discussed at length by Gossen in *Chamulas in the World of the Sun: Time and Space in a Maya Oral Tradition* (1974). He discusses the phenomenon of "language for rendering holy," in Chamula ritual tradition. The "language for rendering holy" is remarkable because, as Gossen tell us, among the Tzotzil Maya, and probably by extension, to other Maya language groups, it "shares with other ritual symbols the qualities of increased heat, expressed in its case as multivocality and redundancy of message" (Gossen 1974:161).

Related to the heat metaphor is the fact that deities consume essences and humans consume substances. This is one of the reasons that ritual speech, music, candles, incense, tobacco, rum, fireworks, flowers, and leaves accompany most Chamula rituals. They emit heat, smoke, aroma, or sound, which serve as the gods' food. Men may participate in the religious experience by consuming, producing, or simply being in the presence of the gods' ritual substances. Formal language is one of these substances.

This provides us with further evidence that the odor, heat and light that copal emits, and other forms of incense, are the substances and qualities which perpetuate creation, the gods, and the well-being of humans. One modern prayer demonstrates an example of a Maya petition and transformative language employed during ritual (Breedlove and Laughlin 1993:49-65):

> One lowly torch,
> One humble candle,
> One lowly chunk of incense,
> One humble cloud of smoke,
> One lowly flower,
> One humble leaf,
> Of your lowly children,
> Your humble offspring.[26]
> For them I beg holy pardon,
> For them I beg divine forgiveness.

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[26] The authors specify flowers and leaves as references to cane liquor. N. 4, p. 65.

Table 5.4 Tzotzil terms characterizing plant exudates from various sources (based upon Breedlove and Laughlin (1993:450)

tzonok'	resin used to plug leaks in water jugs and splits in soles of feet, incense (e.g., *Pinus montezumae* var. *rudis* (Pinaceae), *Enterolobium cyclocarpum* (Fabaceae)
xxuch'al	resin, incense, sap (wild fig, gumbolimbo)
xuch'ulik	resinous (pine)
ya'lel	sap, raindrops falling from tree, "its water"
xchu'	milky, "its milk" (e.g., *Stillingia acutifolia* (Euphorbiaceae), *Ficus cookii*, *F. cotinifolia*, etc. (Moraceae), *Jatropha curcas* (Euphorbiaceae), *Thevetia ovata* (Apocynaceae), etc.
xch'ich'el	red sap, "its blood" (e. g. *Quercus rugosa* (Fagaceae), *Jatropha curcas* (Euphorbiaceae)
spojoval	milky sap, "its pus" (e.g., *Stillingia acutifolia* (Euphorbiaceae)

The offerings provided by the speaker are constantly referred to as humble, as pittances; their essence as divine foods seems to be more important than their purchase value. Many prayers are beseechments for protection from poor harvests, natural phenomena, and poor livelihoods.

Gossen's (1974) study of the oral tradition and cosmology of the Chamulas includes an appendix of ancient narrative, stories which "represent a true account of the past, in which Spaniard and Catholic saints interact as coevals with earth gods and sun and moon deities." Two of these texts are provided here and provide insight into the role of copal in indigenous Maya cosmology (Gossen 1974:334).

> *The Food of the Gods*[27]
> A long time ago [in the time of First Creation], white candles were made of the tallow of a sea animal. They are very important for the whole world because they are the food of Our Father. Now candles are made of paraffin and painted all colors, so people can select the ones they want. Striped candles are for our souls. They have their counterparts in heaven. Those of us who have long candles will live to be old. Green candles are for prayers to Our Father. Tallow candles are the food of Our Father. Incense trees grow only in the Hot Country. Our Father passed through there planting them, for it is the favorite food of the saints. That is why incense and candles are used by the ritual officials and people who want to give a gift to Our Father.

In this description of the significance and origin of resin trees and the burning of incense and candles, we learn that 1) in ancient times sacred materials for candles came from very great distances, and their procurement was difficult, 2) that tallow candles are food for the Creator and the saints and that incense is strongly associated with candles, 3) incense source trees were planted and cultivated for human use by

[27] Titles have been arbitrarily assigned by Gossen, who warns against sociological interpretation and identification and provenience of text motifs. The two texts examined here are based upon information given to Gossen by Manuel López Calixto.

Our Father and that these source trees grow only in the hot lowlands; the procurement of incense remains difficult and that there is long-distance trade of them into the highlands, where it is too cold for these trees to grow, 4) that incense is the favorite food of the saints (and other native deities), and 5) that candles and incense remain a divine gift of choice for the Chamulas.

The second text is a curious one (Gossen 1974:343):

> *The Rabbit and the Resin Doll*
> Our Father was clearing the brush for his milpa and discovered that a rabbit had magically caused the brush to reappear every night. The third time he put pieces of resin at the four corners of his milpa to catch the rabbit. The resin was shaped like a person. The rabbit got caught after having an argument with the resin doll. Our Father came and punished the rabbit, pulling his ears until they were long. The rabbit fled into the woods. Then our Father sowed beans, squash and maize. He made us from clay. Our arms did not move nor did we want to eat the grass Our Father offered us. We wanted to eat Our Father's body, and that was the origin of maize. It was his body, which he gave to us.

In the *Rabbit and the Resin Doll* story the entire world lies within the cosmic milpa of Our Father. This agricultural creator fashioned resin into the shape of a person, with whom the rabbit had an argument. Did Our Father animate the resin doll in the milpa for just that moment in time, for the purpose of tricking and catching the rabbit? Or was the resin already animated, incorporating properties and principles of the living? The rabbit had to be chased off, into the woods, the "wild," so that the planting of the milpa, and therefore the cultivated, agricultural world which supports humans, could commence. Today, throughout the Maya area, after the clearing of wild forest or fallow lands and at the advent of the agricultural season, planting and rain rituals are held by the community and by individual farmers in their milpa, and copal is burned to help solicit rain and abundant harvests from the appropriate rain deities, and protection from winds and animals (Don Benjamin, pers. comm.). Recall that the Ch'ortí Maya farmer of Guatemala pairs gruel and copal together in his planting ceremony offerings. They are companions, which "may indicate their connection with the idea of fertility, and therefore symbolizes the dual-sexed earth deities to whom the ceremony is directed. It is believed that the maize plants are born of the union of the two-sexed pair." Four maize ears fashioned from copal resin are placed in the maize crib to guard the crop (Wisdom 1940:442, n. 15). The parallels between actual ceremonial Ch'ortí agricultural practices and Tzotzil Maya creation-agriculture legend are striking in regard to role of resin as both an animated substance and its symbolic fertility.

Vogt's *Tortillas for the Gods* (1976:49-50) includes a discussion of the symbolism of *pom* incense use in Zinacanteco ritual. His informants reported that the smoke provides a "good and rich" smell, and that it is "cigarettes for the gods." Vogt found two types of *pom* in use: *te'el pom* (tree incense) and *bek'tal pom* (flesh incense), but does not provide the botanical sources (most likely the Burseraceae, as in the Chamula community). *Te'el pom* is made directly from wood chips; the tree sources are considered "wild and undomesticated." *Bek'tal pom*, on the other hand, consists of nodules of resin, "which requires that the tree be cut in advance" (he implies that incisions or cuts are made in the standing, living tree). The resin is allowed to collect, and is then formed into balls, "in other words, something that requires more human activity, something more 'cultural' than the wild 'tree incense.'" During rituals, in which the gods are fed, censed, and smoke their cigarettes, copal comes to symbolically represent heat, a quality and property used to warm newborns, victims of soul-loss and related illness, a quality shared by new candles. Vogt argues that the transformative properties of copal (like those of candles), from a solid to a gas, help to render it holy. I would like to suggest that the symbolic properties of copal are similar to those of candles:

> Thus, the candle flame symbolically combines the two forms of power Zinacantecos most respect—'heat' (health, strength, authority) and 'sight' (ability to communicate with the gods); it embodies their interrelation and demonstrates their possibility of linking man with the divine (Pope, unpublished manuscript, as cited by Vogt 1976:207).

Copal and the Tzotzil Maya: a brief summary

We have learned from the Tzotzil Maya that *pom* and other incense are part of a "debt-payment" concept between humans and gods, and which sometimes functions as a gift, as with cigarettes. *Pom*, like candles, is conceived of as a divine food, and the burning of incense is a critical preliminary stage in all petitions to the gods. The Tzotzil have a well-studied plant classification system in which the Maya word for copal, *pom*, is a categorical set encompassing only members of the Burseraceae. In addition, the resinous wood of *Bursera* species is used instead of resin exudates. Certain kinds of *pom* are held in higher regard than others, and the taxonomic sources of these types is discussed. A very brief indication of the richness of Tzotzil plant and plant product classification is given, but is beyond the scope of this discussion. The Tzotzil also provide the first instance in which resins form part of a story, especially a creation story, in which the origins and functions of resins are described. These stories are the most explicit statements I have been able to find regarding copal's meaning and significance to any Maya. Pines are also an important source of resin products, although, again, the main source is wood. The explicit role of language and the metaphors of heat, odor, and light, as related to essences which perpetuate creation, the cosmos, and the well-being of gods and humans, is described. Few domestic uses for resins were described, with the exception of the maintenace of musical instruments, where the whitest resins from the "*pom*" set (Burseraceae) are used as rosin for fiddle strings (Breedlove and Laughlin 1993:179).

The Lakandon Maya of the state of Chiapas, Mexico

The Lakandon Maya of southeastern Chiapas, Mexico, live near the famous sites of Palenque, Yaxchilán, and Bonampak (Fig. 47) and present a vivid example of the ritual use of copal in Middle America. The Lakandon are unusual in that they constitute a small pocket of Yukatec Maya speakers, surrounded by Chol and Tzetzal Maya speakers; they are probably fairly recent migrants to the area (McGee 1990:18). Alfred Tozzer (Tozzer 1978) studied the Lakandon at the turn of the century and believed that although differences in the Lakandon and the peninsular Yucatec Maya language were few, the differences in lifestyles, customs, and histories since the Conquest, were striking. Tozzer also proposed that the religious customs and practices of the Lakandon had survived from the time of the ancient Maya of the Yucatán and from the Maya as a whole, based upon Landa's descriptions of Maya culture in the 1500s (Tozzer 1978:1, 79; McGee (1990) also agrees with this hypothesis). The Lakandon Maya have lived in relative obscurity since the colonial period and resisted conversion to Catholicism until this century. At the time of McGee's (1990) research into the rituals and religious beliefs on the Lakandon in the 1980s, there was only one non-Christian Lakandon settlement left, that of Najá. In addition, the total number of Lakandon Maya is very small, perhaps five hundred.

In regard to which term was used by the Lakandon for resin used as incense, Tozzer tells us that "It is called *copal* by the Mexicans and *pom* by the natives"

(Tozzer 1978:20). Furthermore, in the original Lakandon texts provided by Tozzer, the term used is clearly *pom*. According to Barrera Marin *et al.* (1976:414), the Yukatek Maya term *pom* means "that which is for burning." This meaning is more akin to the general term for incense, copal, than to the specific sources referred to by the term *pom* among the Q'eqchi' and Tzotzils. McGee uses copal and *pom* interchangeably and it is not clear from his translations of Lakandon oral traditions which term is used today. I use the term *pom* here in respect of Tozzer's determination except where original texts use copal. In Najá the use of *pom* has been common and the Lakanodon provide us with some of the best details regarding its functions and properties among modern Maya.

Taxonomic identity of copal trees in the Lakandon region

Tozzer cites *Protium heptaphyllum* (Burseraceae) as the source of an "incense" used in the religious ceremonies" of the Lakandon and other Maya of the area. "....The sap of the rubber tree (*Castilla elastica*, Maya *kik'* ') is also used as incense among the Lakandones. A pitch pine (Maya *tôte*) is used for light in making journeys at night. It burns with a slow steady flame" (Tozzer 1978:20). Roys agrees with Tozzer's taxonomic designation of *Protium heptaphyllum* as the primary source of copal, and also includes *P. copal* (Roys 1976:277)

McGee, on the other hand, cites the source of copal or *pom* used by the Lakandon as *Pinus pseudostrobus* (Pinaceae), a species also used by the Tzotzil of highland Chiapas (but which, according to Farjon *et al.* (1997:130), does not extend as far west as the Lakandon area). He states that young boys are responsible for gathering the resin (in contrast to collecting methods in Lanquín, Guatemala), which is collected by making shallow diagonal incisions in the bark of the tree. The exudate flows along the incisions and collects in a leaf cup at the base of the tree, is pounded into a thick paste, and stored in large gourd bowls in the god house (McGee 1990:44). Tozzer and McGee also provide the most thorough discussion of the use of elastic rubber in Lakandon ritual. Rubber is an offering associated with the *xikal* (see below) (Tozzer 1978:127; McGee 1990:90-93) but is also referred to as incense by both authors.

Resins in religious ceremonies, everyday life, and medicine

First and foremost, the use of *pom* is intimately associated with the *balché* ritual and god-pot renewal ceremonies, probably the most important rituals retained by the Lakandon today; presumably all the men of the Najá community participate in these events (women are largely excluded from the rituals described here). I will discuss the *balché* ritual first because McGee perceives it to be a "structural prototype" for virtually all Lakandon communal religious rituals and religious beliefs (McGee 1990:82-84). *Balché* is a fermented beverage made from honey and the bark of *Lonchocarpus longistylus* (Fabaceae). It is likened to warm, weak beer (McGee 1990:70) and is consumed in great quantities at certain times of the year. Colonial accounts of the Yucatán corroborate the use of this beverage by the Maya of that period, although the ritual and social use of *balché* was lost upon the Spaniards. McGee relates that *balché* ceremonies may be stimulated by a variety of circumstances, but are usually conducted when "supplicants ask the gods for a favor in the face of serious misfortune such as sickness or crop failure (*t'ʔän-ik kʔuh*, to 'call the gods') or as a thanksgiving rite (*boʔot-ik kʔuh*, to 'pay the gods') when they have granted a request" (McGee 1990:73).

As in many other Maya groups, the Lakandon believe that the gods and deities must be fed, with *balché*, ceremonial foods, and *pom*, to ensure the continued help and beneficence of these entities. If these duties are neglected, the gods become angry and deliver poor crop harvests, illness or death, and other misfortunes to humans under their charge. In turn, as McGee states, a man who has made the appropriate offerings fully expects the gods to fulfill their responsibilities to him and to his family (McGee 1990:73). "God pots" are the incense burners used by the Lakandon and the vessels in which the gods are fed *balché*, and other ceremonial foods. An elaborate ritual centered on the production and consecration of these pots is briefly described below. I first present McGee's and Tozzer's descriptions of the significance of *pom* in the *balché* ritual.

Prior to the ritual, the different gods are asked if they would like to participate, and if they answer in the affirmative, their respective pots are taken down and set out in a specific hierarchical order. The god pots (*läk-il k[?]uh*) are placed upon a layer of palm leaves, shielding them from unholy ground, since contact with the ground desecrates the offerings. The palm leaves under the pots, too, are transformed into seats for the gods. Incense offerings (*yo[?]och k[?]uh*, or "god's food") are made before the inception of the *balché* ritual. The smoke of the resin is believed to be transformed into tortillas and the application of a small amount of bitter *balché*, in turn, becomes a larger amount of sweet *balché*. Incense is placed in the god pots with small wooden paddles and are lit with an ember of a virgin fire. Prayers are chanted to the pot while clouds of smoke billow and sputtering sparks arise from it (McGee 1990:76).

Prayers accompany the burning of *pom* in nearly every instance described in the literature associated with the Lakandon. Both Tozzer (1978) and McGee (1990) include prayers and chants associated with Lakandon ritual, although Tozzer's represent a broader array of circumstances and events in which they are used. I provide excerpts of a few of these prayers below because they exemplify, in the translated words of the Lakandon, some of their basic concepts of the cosmos and their relationship to it, and because there are few specific examples of such prayers available in the literature. McGee records one such prayer in which the Lakandon god of hail, lakes, and alligators is literally "paid" incense in return for future protection from misfortune (McGee 1990:76-77):

> Here [for you], *Itsanok'uh*, here is your incense. Take it.
> The payment you speak of Lord of Sky.
> Perhaps now your thoughts will not be cold to me....
> Here is your payment of copal incense, take it!
> For you with my Lord.
> Here for you the payment of copal incense....
> If you have seen me do something [bad] I am sorry, I am not guilty....
> Now I am not guilty...I have not slandered your incense burner.
> I have not spoken badly about your god pot, I have given incense to you here
> I am very happy to see your incense burner.
> Here I have arrived to see it beneath your house.
> It is good that I pay incense to you Lord...here is the payment of incense.

The theme of payment to the gods is clearly stated here. McGee proposes that the man making this prayer is essentially saying, "I am burning incense for you, so if I suffer from pain cure it. If I do something bad, then forgive me because I am making this offering" (McGee 1990:77). Earthly indigenous products (*pom*, annatto, *balché*) are provided to the gods in return for continued benevolence. The manner in which the god pot is addressed also suggests that it is a personification of the particular god addressed, as stated by Tozzer (1978:89) but McGee disagrees. He relates that the Lakandon do not worship the god pots and that they are not believed to be the gods nor accurate representations of the gods. Instead, they are abstract models of human beings, and are the means through which offerings are transmitted to the gods for their consumption. He also rightly points to the similarity between the functions of the god pots and the crosses among the Zinacantán Tzotzil Maya in the Chiapan highlands (McGee 1990:51). The Ch'ortí Maya in Guatemala are also reported to have human heads molded on the crown of incense burners (Wisdom 1940:382).

Turning to the god pot renewal ceremony of the Lakandon, we find even more specific uses of *pom*. For instance, before any important ceremony begins, a period of fasting and offering of prayers is initiated. Sponsors of the ceremonies "bathe" and clean themselves by immersing their hands in the smoke of the burning incense in the god pot, and waving the smoke over themselves as if washing in water (McGee 1990:96). This kind of ritual purification is common throughout Maya society, and serves to perfume, sanctify, and fumigate the space and persons present. A most striking event is the preparation of the *xikal*, a flat piece of wooden board on which incense offerings are molded and arranged. *Xikal* are described by Tozzer (1978:125-126):

> In one case there were eighty of these [nodules of *pom*] arranged in ten parallel rows of eight each. They are of two forms as representing the two sexes, and they are offered in place of men and women in order to carry out the demands of the rites. Those representing men are bidden to go out into the forests and procure game for the gods, and those representing women are supposed to grind the maize and make the different offerings presented to the gods. These nodules are made first in the form of a truncated cone by the aid of paddles of wood. Those male in sex are fashioned by placing a small ball of copal in the

center of the flattened top of the cone and then completely surrounding this with eight other small and round bits of copal. The female nodules are made by placing three flattened round disks of the gum, one on top of the other, on the flattened top of the nodule. The significance of these sexual characteristics is not clear. Five of the ten rows on the board are male in sex and five female. They are arranged alternately.

McGee provides more detailed information on the symbolism of the human body in regard to the construction of the *xikal*. As a Lakandon male places each nodule upon the board, he says, "This is your head, this is your head. This is your arm, this is your arm." The burning of a small amount of copal and chanting over the *xikal* is believed to purify the nodules and to cause them to assume consciousness (Tozzer 1978:118, 183):

> Break! Break! I am half warming (you). Be Alive! Awake! Do not sleep (but) work. I am the one who awakened (you) to life. I am the one who raised (you) up to life above the board. I am the one who reanimated (you). I am the one who raised (you) up to life. I am the one who built up the skeleton. I am the one who built up the head. I am the one who built up the lungs. I am the one who built up the liver. For you an offering of [*balché*]. For you an offering of [*balché*]. I am the one who raised (you) up to life. Awake! Be alive!! (Tozzer 1978:109, 115)[28]

After the completion of this event, the incense is removed from the board and burned in a god pot. As they are burned, the nodules are believed to be transformed into living servants of the gods. (A similar concept is applied to rubber figures and is discussed below.) Copal offered to the god pots is sometimes offered only as crude lumps, called pom, rather than as molded items, called *sil*.

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[28] See Tozzer 1978:128, 178-179, for original text and translation of chant.

God pot manufacturing and renewal has traditionally been a very important ritual among the Lakandon Maya. This event has apparently not occurred since 1970 and may, in fact, be a tradition of the past. God pots are incense burners in which *pom*, other kinds of incense (discussed below), and ritual foods are placed and are the means by which offerings are transmitted to the gods.[29] Each burner is white with red dots and black stripes[30] and can be male or female, depending on the god to whom they are dedicated. The faces portrayed on the pots are literally fed with the ritual foods. According to Davis (1978:73, as cited in McGee 1990:52), god pots are made as a "corporeal replica of the gods to whom it is dedicated," and specific features (eyes, mouth, heart, lungs, stomach, diaphragm) are represented by cacao beans placed within the incense burner bowl. Specific facial features are molded onto the image and the front of the pot is called "the chest," while the bottom is called "the feet." The specially selected stones from sites considered to be the home of particular gods are placed within the bottom of the pot and are considered by Davis to be a kind of transmitter (Davis 1978:74, as cited by McGee 1990). McGee (1990:52) relates that he has heard the rocks referred to as benches upon which the gods sit when they arrive at the ritual hut to receive their offerings. Furthermore, according to Tozzer, palm leaves are waved through the *pom* smoke and then taken to members of the family, who are tapped with the leaves. The palm leaves "are the medium by which the efficient and healing power of the gods as revealed in the smoke of the incense is carried to those who need it. If any special part of the body is afflicted, it is tapped at

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[29] Incense burners, made of clay and with figures molded around the bowl, are well known from the Classic Maya period. Numerous archaeological examples have been found throughout the Maya region. Tozzer (1978:105-122) provides a lengthy description and discussion of god pots and their renewal.

[30] Tozzer (1978:109, 115) identifies the paint media as chalk (white), achiote or annato (red, and discussed more fully below), and copal soot (black).

greater length with the leaves" (Tozzer 1978:121, 175-176). A similar use for palm leaves is reported by Alcorn (1984), among Catholic Huastec Maya of Veracruz, Mexico.

There are additional instances in which *pom* is important to the Lakandon. For example, when a child is initiated into adulthood (*me k'chul*), the usual ritual offerings are made (e.g. *balché*, *xikal*, *pom*, rubber figures, bark cloth headbands, atole and tamales, and gender-related work objects). One of the ritual events is to show the initiate the path to the milpa and the trail leading "to the grove of pines where the family's *pom* incense is tapped." Instructions are also given for tapping the trees but these methods were not specified by McGee's informants.[31] Finally, the father of the initiate stands by his child and chants, assuring the gods that among other things, the offering of incense, tortillas, "the payment," will continue (McGee 1990:102-103). Travelers, before setting out on a long journey, prepare a *xikal*, and offerings are made to the gods "known to be well disposed to the undertaking" (Tozzer 1978:147).

On a more cosmic level, there is a Lakandon myth in which an immortal human, *Ah Lehi Kah Bäh* (Trapper of Moles), also known as *Nuxi* (Ancient One), was given a tool, the *asab* ("the Awakener"), by the god of death. With the help of his *asab*, *Nuxi* resurrected the dead wife of one of his companions because he was so lonely for her. While out tapping his incense trees, *Nuxi* was betrayed by his wife, lost the power to wield the *asab*, and died of fever. According to the Najá Lakandon myth, the death of *Nuxi* meant that all humans must die. The death of *Nuxi* was not the end of his existence, however, because he went on to lead another life in the underworld (Bruce, 1982, personal notes as given to McGee 1990:106-107). To the

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[31] It would be interesting to know how the Najá Lakandon community distributes and utilizes its forest and resin resources. Missionary work, clearing of mahogany trees, and an increasing tourist economy throughout the area have resulted in a rapidly changing community. Land ownership, if it exists as a private or public institution, may also be in a state of dynamic change.

Maya, death is not the completion of a single act, but a transformative episode, and the beginning of another state of being. I include this story to demonstrate how certain creation myths refer to the all-important collection of incense, even by the ancient ancestors. *Pom* is both an earthly and mythic element which initiates transformative acts and must be fed to the gods. As McGee cogently states, "the ritual principle operating in this belief system is that reversals [bitter *balché* into sweet, *pom* into tortillas or payment, the transformative act of death] occur when an object changes levels of the universe" (McGee 1990:107). *Pom* smoke travels to these different layers as an essence of the earthly foodstuffs because of the transformative nature of ritual, and *pom* satisfies the hungry gods. Curiously, *pom* does not seem to be part of the materials enclosed within Lakandon burial mounds.

One final example of the transformative processes embedded in Lakandon religious beliefs is found in the *nahwah* ceremony. Again McGee (1990:84-98) provides much information on this ritual and the reader is referred to this author for full discussion of the sacrificial symbolism of this ceremony. Briefly, *nahwah* is a tamale made of maize and served with a deep red sauce made from *k*ˀ*uxu* (annato, *Bixa orellana*, Bixaceae). *K*ˀ*uxu* is a red vegetable dye that is also used to paint the god pots, the ritual hut, the bark cloth headbands, and the ritual participants themselves. According to McGee's informants, both foods (within the last 150 years or so) were recently designated as substitutes for the human body and human blood, and are offered to the gods with *pom*. The substituted symbolic materials are then transformed into the "real" material. Mythical and ethnohistorical sources strongly support a pre-Columbian precedent for the sacrificial ritual and accompanying beliefs in modern Lakandon society.

Pom is one of the few nonedible offerings made to the gods by the Lakandon, but remains the principle foodstuff of the gods (McGee 1990:44). Actual foods offered to the gods include tamales filled with beans or meat, atole (a maize gruel), and cacao (a beverage). A striking use of rubber is made by the Lakandon Maya. Briefly, latex, presumably from *Castilla elastica* (Moraceae), is molded into humanoid figures that accompany the *pom* nodules on the *xikal* and are burned with the pom. These rubber figures are called $k^{?}i\ k^{?}$, and again serve as sacrificial substitutes for humans. Up until the 1950s these figures were painted with blood from Lakandon men; today human blood is substituted with $k^{?}$*uxu*. The word $k^{?}i$ *k'* is the Maya root for blood, a term also encountered among the K'iché Maya of northwestern Guatemala and where it is applied to both blood and to the red exudate of a member of the Euphorbiaceae.

Finally, there is again a disturbing interchange of the terms incense, *pom*, and copal in the ethnographic and ethnohistorical sources for the Lakandon. It is not possible to cipher whether any real distinction exists between plant resins called *pom* and those used merely for incense. This trend may be an artifact of our own loose definitions of incense: any aromatic, smoky-burning material. More careful study of the Lakandon might invalidate or support the reported evidence for plant resins with different purposes for different situations.

Pom *and the Lakandon: a summary*

The Lakandon provide further evidence of the ritual and social significance of *pom*. The renewal of incense burners, the manufacturing of *xikal*, and accompanying ritual language, all point to the transformations which sacred substances, like *pom*, *balché*, and maize, undergo to become food for the divine. There is some confusion about the sources of *pom* and clearly better botanical assignations are required.

Copal in the modern medical traditions of the Maya

The phytochemical properties of plant resins are closely tied to their terpene and phenolic constituents. Terpenes and phenolic compounds are known to be anti-inflammatory and anti-microbial and are used as such in cough syrups and ointments in the industrial world. It is unlikely that many of the Maya are aware of the "scientific" values of resinous compounds, but through at least a millenium of trial and error, they have obtained some empirical evidence of the efficacy of plant resins in the reduction of swelling, fevers, and infection. They may also use copal as an analgesic, though the evidence for that is scant and weak at this time. In sum, copal's phytochemical properties lent themselves (and their various forms and taxonomic sources) to incorporation in the Maya repertoire of natural plant medicines. The Maya also extended copal use to the treatment of illnesses not recognized by industrialized cultures: susto, soul loss, and enchantment or possession of the body by evil spirits. Copal is also used in treatment of many diseases as a substitute for the human body and the illness is encouraged to take up residence in the copal instead, which is then destroyed and the illness with it.

The role of copal as a medicine in the indigenous Maya pharmacopoeia is striking. In conjunction with the ethnographic literature presented in this chapter, fieldwork data collected by the author in 1993 and 1995, and with Appendices 1 and 4, it is clear that there are several categories of illness in which copal plays a significant role. While this study does not attempt to theorize on the diagnostic concepts and general medical traditions of the Maya, it is useful to consider the role of copal in one model of indigenous epidemiology.

In his discussion of the framework of indigenous medicine, Logan (Logan 1978) identifies four epidemiological criteria which characterize therapeutic treatment in nonindustrialized societies. These criteria can be used here to begin evaluating the therapeutic properties of copal:

1) Treatment of a natural injury, like burns or snake bite
2) Disruption of internal harmony of body, like soul loss, bad airs
3) Intrusion of foreign objects into body, such as worms, evil spirits
4) Malevolent activity of human or supernatural agenicies underlying witchcraft

I contend that copal and plant exudates, by extension, meet these four criteria, and serve as indigenous agents against illness and disease. Copal also meets some of the Western qualifications for disease or illness treatment, by virtue of its terpene and phenolic constituents. Copal should, perhaps, not be dismissed as a mere "indigenous" remedy, but be investigated more fully by ethnobotanists and natural product chemists alike.

Selected Colonial references to copal in the Maya cultural region

In this section I address some significant historical references to the use of *pom* or copal. These references are important because they demonstrate the widespread use of plant resins at the time of the Spanish arrival to the Americas, and because they provide some insight into the role of copal in Maya cosmology during the colonial period. Important resin artifacts found in the Yucatán serve to demonstrate the presence of plant resins in prehispanic Maya society. A final source is presented to demonstrate the European excitement about natural products, especially for plant resins, discovered in the New World.

Selected Spanish references to copal and incense in Mesoamerica during the Colonial period

There are numerous colonial (Spanish) references to copal and *pom* in the Colonial literature, especially in Tozzer's (1941) translation of Bishop Diego de Landa's *Relación de las Cosas de Yucatan*, which I consider below. There are so many minor and often obscure sources with references to its use by the Maya, in fact, that I have chosen to present just a few clear examples representing contemporary Spanish attitudes and observations of copal use. For instance, Tozzer (*Relación del Pueblo de Mama* ([1580], RY, I:169, as cited in Tozzer 1941:75, n. 338) refers to a sixteenth century description of *pom*:

> There is a tree which the Indians call *pom*. It is about as large as a large fig tree. Upon striking some blows all around it and leaving it for two days it distills from itself a resin-like turpentine, except that it is harder and very white. The Spaniards call it copal, and it smells very good and has many virtues with which the Indians heal themselves. And the Spaniards value it for bilmas [poultices] and many other things. The natives used this fume a great deal, for they offered it as a *sacrifice* to their gods. The said tree is found in this said pueblo [Mama] and they come in search of it from more than twenty leagues around because it is not there.

Landa (Tozzer 1941:152) refers to *xikal* (similar to those made by the Lakandon today) in sixteenth century Yucatán:

> It was at this time that they chose officials, Chacs, to assist the priest, and he prepared a large number of little balls of fresh incense upon little boards which

> the priests had for this purpose, so that the fasters and abstainers might burn them in honor of their idols.

Yet another work by Tozzer (1984) is a translation of a Spanish manuscript at the Archives of the Indies at Seville. The letter was written by two Franciscan priests, and is dated 1696, an early colonial reference for the Lakandon area. Besides the numerous general observations by the authors of the use of copal, is the postscript of the letter:

> Referring to metal and precious stones, they have none, neither have they aromatic spices unless it be vanilla which grows in these woods, and many *palos de Maria*[32] and balsams, of which, as a sample, we send a piece of bark which we use as incense. There are also some copal trees....

Of additional interest is the distinction by the Spanish authors between balsams and copals, and the absence of clear information as to differences between the two products, and their respective uses and functions. It is implied that the balsams are used as incense, yet the envoys sent a bark sample to the king of Spain instead of the balsam product itself. What constituted a balsam for the Spanish and in what way did it differ from copal? Are balsams more fluid than copals? Are Maya copals also used by the Spanish as incense or not? Copal trees are once again spoken of as a well known type of tree, commonly known by Europeans, but no clues are given to either its identity nor its potential use in Catholic ritual. In the additional notes of the 1984 edition of the same letter (Tozzer 1984:15, n. 60), the editor identifies the sources of copal as "the aromatic resin of several tropical trees, principally *Protium copal*, *P.*

[32] *Palo de Maria* is cited by the editor as *Calophyllum brasiliense* (Clusiaceae) and its common name, *leche maria* is also applied to other species of this genus elsewhere in Central America. The exudate of this tree is most likely a latex (chemically, that is) with putative healing properties.

heptaphyllum, and *Elaphrium gracilis* [*Bursera* spp.]," but provides no source for his determination.

Another set of colonial sources with implications and data relevant to the study of Maya ethnobotany are the *Chilam Balam* texts, written by peninsular Yukatek Maya in Spanish and begun in the sixteenth or seventeenth centuries. These texts are historical, in that they include numerous descriptions of political events and development in the area over a long period of time, and it is thought that some of the knowledge and events were conserved and derived from pre-Contact Maya codices (Edmonson 1986; Restall 1998). Ralph Roys (1931, 1978) compiled the medicinal, ritual, and domestic data from several of the *Chilam Balam* books (of which there are many, possibly upward of fifteen) and several other sources to produce *The Ethnobotany of the Maya*. Among the information Roys found is the following (*Yerbas y Hechicerias del Yucatan* n.d., as cited in Roys 1976:277):

> *Pom*. Copal, which is the incense of this land (*Motul Dictionary*). This tree, *pom*, is the copal, as they call it. It is heating [referring to its warming properties, I believe] and so useful a tree that its resin, which is like incense, is what they ordinarily use in the poor churches. The Indians commonly use it in their idolatries.

Roys also identifies the botanical source as *Protium copal* and cites a tantalizing statement given in the *Chilam Balam of Chumayel*, that the "gum...is called the superodor of the center of heaven...and the brains of heaven" (1931:36, 38, as cited in Roys 1976:278). There is no further discussion of the meanings and implications of the statement, which raises more questions about the native concepts underlying the use of copal or plant resins as divine food, as incense, and as medicine. If the statement had said "blood" of heaven, rather than "brains of heaven," the course toward development of a theory of copal-blood association would be clearer. I have not encountered any other reference to copal with such explicit attributes, with the exception, perhaps, of the Kiché *Popul Wuj* (see below), but which is less categorical. I resume consideration of this statement in the conclusion of this chapter.

In Feldman's *A Tumpline Economy: Production and Distribution Systems in Sixteenth-Century Eastern Guatemala* (Feldman 1985), the author reports that resins were a significant market item. The Spaniards were apparently most familiar with copal from *Protium copal*, "sown and cultivated" in the "hot and humid lands" of Verapaz (Montero de Miranda 1954). The Kakchiquel are reported to have recognized four kinds of incense: *yalahpom*, or crude incense, *chakihpom*, or dried copal, *bok* or *pixtun*, copal rolls, and finally, *mukmuxcay*, incense burned in incensarios. Feldman (1985:80) points out that the terms also "describe the modern stages in the movement of the product from the tree to the censer." He cites other resins that were specifically important to the European market during the colonial period. These resins were from *Myroxylon balsamum* var. *pereirae* and *Liquidambar styraciflua*, which are technically balsams. Nonetheless, balsams acquired a great deal of attention from colonial commentators. Feldman asserts that "copal was, for the Indians, the most important of the resins" (presumably from *Protium copal*), and found that only four towns produced it in the sixteenth century, one of which is Cahabón (Feldman 1985), a town very close to Lanquín, Alta Verapaz, and in a roughly similar vegetative zone (though it possesses more tropical vegetative elements).

In 16th-century Guatemala liquidambar balsam was held in high enough esteem to be exported to the Old World as incense (Ximénez 1967:244-245). According to Ximénez, liquidambar was abundant in Rabinal (in modern Baja Verapaz, Guatemala) and mountains northward during the 17th and 18th centuries.[33] It is thus expected that liquidambar might continue to be an important source of resins in Baja Verapaz, Guatemala.[34] The species can be found growing in small stands along the highways and secondary roads but no evidence of collection was found during my field work, however.

A selected indigenous reference to copal in Mesoamerica during the Colonial period: The Popol Wuj, a Maya cosmology

Moving from the present period into the historical past demonstrates continuity in the use of copal through the centuries, but a direct explanation for its meaning and symbolism is still lacking. Where did the concept of plant exudates as sacrificial offerings originate? What properties were early attributed to resins to warrant their widespread use across Maya society? Are there native documents which can illuminate these issues? The final major source colonial source considered here is of K'iche', not Spanish origin—*The Popol Wuj* (or *Popol Vuh*, in the old orthography), or *Book of the Council of the Mat*. The sixteenth-century manuscript was discovered in the Church of Santo Tomás, in the now famous town of Chichicastenago in the department of Quiché, Guatemala. Dennis Tedlock (1985) deftly translated the manuscript into English and provided an informed interpretation of the myth. The *Popul Wuj* is outstanding among indigenous sources, in that it presents a series of creation stories, originally recorded in both the Quiché and Spanish languages. The

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[33] Liquidambar (*Liquidambar styraciflua*), is believed to have been an important tributary item to the Aztecs, as listed in the Mexican *Codex Mendoza* (Peterson and Peterson 1992). It is believed to have been collected in the cloud forests east of the Valley of Mexico, as were quetzal feathers, a primary tribute item.

[34] It was impossible to travel to Rabinal during the field work period due to dangerous social conditions during a series of major strikes near the Salamá-Rabinal crossroads.

availability of these Maya origin stories has been critical in the modern decipherment and interpretation of iconographic texts, sculpture, ceramics, rituals, astronomy, and numerous facets of ancient and modern Maya cosmological beliefs throughout Mesoamerica. It is considered by some scholars to represent pan-Mesoamerican beliefs in the century following the Spanish colonization. The creation stories in the *Popol Wuj* convey a small, but critical amount of, information pertaining to prehispanic conceptions of resins and copal as sacrificial offerings to the gods.

The *Popol Wuj* describes, in part, the adventures and mishaps of two critical characters, Hun Hunahpu and Xbalanque, in the Underworld. Hun Hunahpu will eventually father two sons who share these names, but who are more commonly known as the Hero Twins. The first direct mention we have of exudates in general and resins and/or latexes specifically, is when Blood Woman, the future mother of the Hero Twins, approaches the calabash tree where Hun Hunahpu's head has been hung after his death at the hands of the Lords of Underworld. It is forbidden for anyone to go near this tree but Blood Woman, the daughter of one of the Lords, is amazed by the story and her curiosity is piqued:

> She went all alone and arrived where the tree stood. It stood at the Place of Ball Games Sacrifice:
> "That? Well! What's the fruit of this tree? Shouldn't this tree bear something sweet? They shouldn't die, they shouldn't be wasted. Should I pick one?" said the maiden.
> And the bone [skull] spoke; it was here in the fork of the tree:
> "Why do you want a mere bone, a round thing in the branches of the tree?" said the head of One Hunahpu when it spoke to the maiden. "You don't want it," she was told.
> "I do want it," said the maiden.
> "Very well. Stretch out your right hand here, so I can see it," said the bone.
> "Yes," said the maiden. She stretched out her right hand, up there in front of the bone.

> And then the bone spit out its saliva, which landed squarely in the hand of the maiden.

And then she looked in her hand, she inspected it right away, but the bone's saliva wasn't in her hand (Tedlock 1985:114). Blood Woman is impregnated by the spittle of Hun Hunahpu. When her father discovers, he orders that she be sacrificed and her heart brought to him. When the guards realize that she carries the child of Hun Hunahpu, they devise a way to trick the Lords of the Underworld. Blood Woman tells the guards that from now on, "only blood, only nodules of sap, will be theirs [the Lords of the Underworld]. So be it that these things are presented before them, and not that hearts are burned before them. So be it: use the fruit of a tree, said the maiden." She gathered red tree sap into a bowl, and after it congealed, "the substitute for her heart became round. When the sap of the croton tree was tapped, tree sap like blood, it became the substitute for her blood.....When the tree was cut open by the maiden, the so-called cochineal croton, the sap is what she called blood, and so there is talk of "nodules of blood" (Tedlock 1985:116). Deceived by the substitute, the Lords dry the sacrifice over the fire, "and [they] savored the aroma. They all ended up standing here, they leaned over it intently. They found the smoke of the blood to be truly sweet!" (Tedlock 1985:117). Tedlock explains the use of the term "only blood" in the above passage as a literal translation of *kik'* (blood), which also refers to "gums and resin from trees, in this case the blood-red resin of the cochineal croton" (*Croton sanguifluus*, Euphorbiaceae) (Tedlock 1985:275, 334). The latex dries into "scabrous" nodules, and it just such a large nodule sacrificed to the Lords, and established as an appropriate offering to them" (Tedlock 1985:275, 334). Cochineal croton does produce an exudate, but technically it is a latex, not a resin or gum. While it is clear that the "cochineal croton" is not a dispenser of resin in terms of the chemical definition, the example illustrates one means by which exudates became important to Maya cosmology at an early date. It is only copal and "cleanly blotted blood" that are burned to the other gods of creation, while those of the underworld gods are denied these gifts.

Determining the qualities which plant resins possess and which renders them so sacred is still subject to discussion. For instance, Freidel *et al.* (1993) recently suggested that plant resins are one in a suite of materials perceived by the Classic Maya (about A. D. 400-900) as possessing or signifying *itz*, defined by Barrera-Vásquez (1980:272) as "milk, tears, sweat, hardened or thickened gum from tree, bushes, and some herbs." Friedel *et al.* (1993:411, n. 19) contend that

> [*Itz*] also means the wax that melts down the side of a candle and the wax from honeycombs, resins and gums used to dye cloth [a use I did not encounter in my research], rust, juice, as well as all body fluids like semen, sweat, and tears. In proto-Cholan (Kaufmann and Norman 1984:121), *y-itz* is "pitch, sap, resin," and there is an equivalent root *iitz* reconstructed for proto-Maya. *Itz* is the magic stuff brought forth in ritual and as secretions from all sorts of things—living and (to us but not the Maya) inanimate.

This idea suggests that copal, by virtue of its secretory nature (supported by linguistic evidence) is a magical substance with animate properties, but does little to explain *why* secretions are so important.

Ch'ulel, a concept common in the western Maya highlands, is a force or quality perceived by modern Maya as "soul," and one which is possessed by many animate as well as inanimate objects (Holland 1989). Soul is intrinsic to human nature, and portions of it can be lost. Copal shares some of the qualities of "soul." It is nourishing animating and aids in soul recovery, at least among the Q'eqchi'.

This is only a brief introduction to these concepts and unpublished disagreements on the subject abound. In addition, a discussion of the epigraphic and linguistic evidence for *itz* is beyond the scope of this study. Consideration of the concepts of *itx* and *ch'ulel*, however, can lend insight into the story of Blood Woman and her impregnation by Huh Hunahpu's saliva and her offering of a "resinous" substitute for her heart. The "spittle" is the magic secretion that is, or represents, the essence of being. Resins are plant secretions which may, in the eyes of prehispanic Maya, have animated the tree and been acquainted with life-giving blood or soul; as such, the use of resins in ritual—as sacrificial offering, as a portal to communication with the divine, and as food and payment, and as medicine, may have their origins in such a concept. The *Popul Wuj* does not state this explicitly, but there is no reason that it should, since it is unlikely that it was written for Catholic priests or Spanish rulers, but rather to preserve ancient Maya oral tradition. The dialogue between Freidel *et al.* (1993) and Holland (1989) is a provocative one, and deserves further scrutiny.

The *Popul Wuj* also identifies three other kinds of pom, whose identities and characteristics I was unable to establish. They are *cauiztan copal*, *mixtam copal*, and *cabauil copal*, all of which were used to incense the direction of the rising sun during its first ascent (Tedlock 1985:181). These different types of copal were brought by the K'iché lineage heads from their ancestral home, Tulan, in the east, but Tedlock's informant (1985) suggests that *mixtam* might refer today to copal from the Mam area to the west, whose copal is highly esteemed by modern Maya (Tedlock 1985:350). Within the *Popol Wuj* is another reference to the "brains of sky," as first mentioned in a Yukatán source above (Roys 1976:278). In this passage, the head of Hunahpu's son, has been cut off. His twin brother fashions a new head out of a squash, and "this became a simulated head for [his brother]. His eyes were carved right away, then brains came from the thinker, from the sky. This was the Heart of Sky...who came down....The face was finished too quickly; it came out well. His strength was just the same, he looked handsome, he spoke just the same" (Tedlock 1985:145).[35] The relationship between copal, "the brains of the sky," and "the superodor of heaven," remains unclear, but should be considered as new texts or sculptural inscriptions come to light.

There are numerous other references to the burning of copal as a sanctifying agent, as a memorial, and as ritualized obligation (Tedlock 1985:especially p.158, and notes, pp. 293-294). One final type of copal burned to the ancestral gods in the *Popol Wuj* is *sol*, consisting of "bits of pitchy bark, along with marigolds" (Tedlock 1985:185). Tedlock identifies this resin as "gummy nodules' collected from the trunks of various trees, and that "bits of pitchy bark are *rachak nooh*, literally 'leavings of pine resin,' pieces of bark on which a hard red resin has been formed as a result of the holes bored by worms." According to Tedlock's K'iché informant, this offering is considered a poorer offering than copal (Tedlock 1985:306).

Tedlock defines the term "*pom*" as proto-Mixe-Zoque, and states that the primary ingredient is resin "from the bark of the *palo jiote* tree (*Hymenaea verrucosa*)" (Tedlock 1985:332). In my experience, in the Maya cultural region, the name *palo jiote* is restricted to members of the Burseraceae, specifically *Bursera simaruba*, and is not applied to *Hymenaea* (Fabaceae) at all, but perhaps in the Quiché region this general finding does not hold. In addition, *Hymenaea courbaril* is the only known species of the genus to occur in Central America but Tedlock is to be excused

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[35] According to a mimeographed source Tedlock examined, *naoh* [*nooh*], is a variety of copal (Maynard and Xec, "*Diccionario preliminar del idioma quiché*," 1954, as cited in Tedlock 1985:287). Tedlock suggests that it is possible that Roys' reading of copal as "brains of the sky," as mentioned earlier in *The Book of Chilam Balam of Chumayel*, might be a pun upon the term "thinker," *ahnaoh*, in which *ah* is an occupational term. I was unable to obtain further information on this type of copal, but see *nooh* later in the discussion; it is possible that *nooh* designates a pine source.

from the taxonomic snarl of his botanical identification. *Hymenaea* is suspected by the author to be the source of some as-yet-unidentified resins encountered in the markets of Quiché, as well as others in the western highlands of Guatemala.

Selected European responses to plant resins during the Colonial period

Resins have long been esteemed by the Spanish and Europeans. The earliest European description I was able to find of these exudates is by Monardes, a Spaniard who, in 1570 or so, wrote the first book describing and discussing natural products from the Americas; it was translated into English by John Frampton in 1574 and called *Joyfull Newes Out of the New Founde Worlde*. Monardes supplies an early description of liquidambar balsam, but calls it "*ococoll*," a name very close to the Nahuatl *ocotl*, signifying pine resin. This is a typical mixup in common names and product. I have some confidence in his identification of the source tree as *Liquidambar*, because of some particular descriptive details, but not in his citation of indigenous nomenclature. He provides an interesting comment on alleged use of the resin and plant by the native inhabitants (Monardes 1925: (I) 22):

> And it is to be noted, that many doe bryng this Storacke as thinne from the Indias, not so good, for because that thei make it of the bowes of the Trees, cut in peeces, and sodden, and they doe gather the fatnes that is upon it, and that the Indians doe sell the buddes of the Trees where the Liquid Ambar is taken out, made in handefulles, the Indians do sel in their market places, for to put amongest their Clothes, which causeth them to smell, as of the water of Angelles, and for this effect the Spaniardes doe use it.

Apparently, in addtion to collection by incision, balsam could be obtained by boiling the branches in water, perhaps, and collection from the branch buds, which are, in late fall through spring, typically covered in resin, perhaps as a deterrent to herbivorous or insectivorous grazing. The branch buds may have been collected by the natives and used as a perfume, as a kind of "deodorant," to sweeten the smell of their cloths and bodies. The indigenous inhabitants, by all accounts, were frequent bathers and kept their bodies very clean, in contrast to, and to the horror of, the Spaniards, who may have later adopted the indigenous custom of sequestering aromatic substances on their person to rid themselves of body odor. I have not yet identified "water of Angelles," but it is likely to be a floral solution with the same purpose.

Balsam of Peru (the balsam of *Myroxylon balsamum* var. *pereirae*) was widely heralded as a miracle balm upon its arrival in Spain. Monardes describes the reception by the medical establishment of this fragrant substance (Monardes 1925: (I) 23):

> When it first came into Spaine, it was esteemed in as muche as it was reason it should be, for that they did see it make marveilous workes, one ounce was worthe tenne Duccates and upwardes, and now it is better cheepe, the first tyme that they carried it to Rome, it came to be worthe one ounce, one hundreth Ducates, after that they brought so much and suche great quantity, that is now of small valewe, this doeth the aboundaunce of thyngs, and when it was verye deere all menne did profite of the vertue of it, and after it came to bee worth so vile a price....Our Lord God did thinke it good in place of that [Egyptian balsam; probably frankincense or myrrh, Burseraceae] to geve us this Balsamo, of the New Spaine, the whiche in my judgement in Medicinall vertue, it is no lesse then that of Egypte, according to the greate effects that wee doe see in it, and the great profite that it doeth, whiche we doe see in Medicines....Seeyng that with one medicine all effectes is doen therewith, beying necessarie, and it is a common thing to saie, that when one is hurte, let Balsamo be put thereunto, and so they doe, and it doth heal, in the woundes of Sennowes it maketh a merveilowes effect, for that it doth both cure and heale, it healeth better than any Medicine doth, it resisteth cold, the woundes of the hedde it healeth verie well, not havying the Scull broken and perished.

Shortly after Monardes' work was published, another Spaniard (García Palacio [1586] 1860) wrote:

> The best balsam was collected between November and May....They say that this balm is a marvellous liquid; and in order to give it greater effect, they extract an oil from the nuts of the trees, which looks like gold...

Monardes held the medicinal value of pine resin nearly equal to that of balsam of Peru. He identifies resins from an unidentified tree as turpentine or "Oyle of Deabeto," and although he states that they are not pine trees, I suspect that they are either a species of *Pinus* or another genera in the conifer family. Abeto is a common name used for pines in the Colonial and in the present period. Monardes provides a brief description of a collection method, in which there are "bladders," or blisters, of two sorts, large and small, from which emerges a "marveilous licour" when broken....The Indians do gather them [the drops of resin] with great deliberation, and they doe put the same droppes which bee in the Bladder into a shell, and alwaies have shells under the bladders, where it doth distill through, and it is a thing doen with suche leasure, that many Indians doe gather verie little all the daie (Monardes 1925: (I) 158). Unfortunately, he does not give a more specific ecological or even geographic location of these trees. Sea shells, if that is what he means, are, of course, ecologically restricted. If the resin collection area was far from the coast, an interesting item of trade would be disclosed. For a broader discussion of the European encounter with New World plant species, the reader is referred to Estes' *The European reception of the first drugs from the New World* (1995).

I would like to very briefly present some data derived from a couple of colonial Spanish archival documents, but primarily from one titled, *Razon de los Generos*

Medicinales que producen nuestras Americas (n. d.).[36] I cross-referenced the major plant products listed in the following documents with Monardes' work, to see what value these products had in mainstream European culture; Monardes describes nearly all of them as medicinal. The *Razon de los Generos Medicinales* is a list composed of four columns: the first is a list of 55 "generos," or genera[37] of plants exported from the Americas, accompanied by two columns describing the part of the plant used and degree of use (little, moderate, or heavy), and its geographical origin; a fourth column, quantities, remains empty. Fourteen of the fifty five *generos*, or approximately twenty five percent, are resin or latex exudates or "gums" derived from such plants as *Liquidambar styraciflua*, *Croton draco* or dragon's blood, balsam of Peru in three different forms and grades, *Copaiba* species (another South American member of the Fabaceae), guaiacum, goma anime, anima copal, caranna, and so forth. New Spain (including modern day Mexico), Louisiana, "America meridional" or the southern part of the modern United States, and Peru, are the points of origin indicated by the documents.

Another important document from the Archivo General, titled *Indiferente 1552* (written ca. 1760), includes numerous short records about trade of various American plants, half of which are from Mexico, and a few from Guatemala. Items such as "simaruba" (*Bursera simaruba*?), "balsamo negro, blanco, and copaiva," "estoraque

[36] I am indebted to Laura Matthew of the University of Pennsylvania, for her valuable contributions to my research. She provided me with a copy of the said document, and with data from other material discussed in this section. The original document resides at El Archivo General de las Indias, at Seville, Spain, which houses a huge collection of unpublished documents, *relaciones* or reports, correspondence, and records. A good portion of the Archive has never been examined at length and there is a good deal of work remaining to be done in regard to studying the biological encounter between New World and Old, especially of economically important plants.

[37] Since the "genera" cited in the document agree with many common names for plants in use today, and as the much of the Archivo documents are concerned with the colonial period, I believe this document can be dated to the pre-Linnean period (prior to the 1750s). On the hand, the scribe may have been unfamiliar with the binomial classification system at the time of writing.

en lagrima" (*Liquidambar*?), and "palo santo" (*Guaicum* species?), are given. *Memoria de los Generos o Drogas que se traen del reino de Nueva España...* (ca. 1750), lists nineteen plant products (Laura Matthew, pers. comm., 1998), of which at least eight are resins, including one "rezina de Tacamahaca" (= *Bursera tecomaca*?= *Commiphora tecomaca*?). These documents amply illustrate the international trade of resins between Europe the Americas in the late colonial period, and demonstrate the alacrity with which Europe "discovered," and traded New World plant resins and similar substances.

I have seen several references made to two significant historical events: the declaration in papal bulls by Popes Pius V in 1562 and Pius IX in 1571, that balsam of Peru could be used as a substitute for the Catholic chrism (e.g., Böttcher 1964:85; Smith *et al.* 1992:253[38]). The chrism is the consecrated sacramental oil used in baptisms, ordination, and extreme unction. In addition, the bulls declared that is was a sacrilege to destroy or injure balsam-producing trees. Martínez (1959a:70) provides a variation of the same theme: the bulls were published and authorized the clergy to substitute the native balsam for "Egyptian" balsam in the consecration of the sacred oils. In order to locate papal bulls, one needs to know the *incipit*, the leading phrase of the document, usually four to five words. I have not been able to locate any such bulls; and although various authors refer to them, no original references have been found. They might provide further insight into the mode of Colonial thought surrounding the popular balsam of Peru.

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[38] Smith *et al.* (1992:253) report that copies of the papal bulls are preserved in Guatemala and the Vatican, but provide no references for further research.

Selected archaeological resin artifacts from the Yucatán

The Cenote of Sacrifice is found at Chichén Itzá, and is one of the most famous ancient Maya ruins, located in the northern Maya lowlands on the Yucatán Peninsula. The cenote is a natural well occurring in the karst formation and is common throughout the peninsula. Rivers and lakes are rare in the area because of the nature of the underlying rock. The ancient Maya were very reliant on artificial wells, caves, and natural wells for their water supplies. A similar kind of reciprocal relationship between humans and gods existed at Chichén as it does elsewhere among the modern Maya; thousands of offerings of ritual objects, gold, ceramic vessels, copper jewelry, and human beings, were made to the Cenote in return for freedom from famine, provision of abundant harvests, and the maintenance of the Maya universe, both before and after the arrival of the Spaniards. Numerous copal artifacts have recently been located in it. Landa provides a first-person description of the site and states that the Maya held "the well of Chichen Itza [sic] in the same veneration as we have for pilgrimages to Jerusalem and Rome, and so they used to visit these places and to offer presents there...as we do to holy places."

A number of copal artifacts were deposited in the Cenote in the Middle to Late Post-Classic Maya Period (A. D. 1250-1539), excavated in the early 1900s and 1960s, and published by Coggins and Shane (1984). Some of the most striking examples of copal offerings consist of effigy figures and effigy vessels, tripod bowls with copal masses, and copal alone. Resin was also found as hafting material and as coatings for wooden idols. Notable among these items is a tripod bowl with a copal and rubber offering. The bowl and the contents were painted "Maya-blue," a color symbolic of sacrifice. Coggins and Shane (1984) describe the copal as filling the bottom of the bowl with fourteen or more rubber balls placed on top and burned. This mixture of copal and rubber is reminiscent of offerings by the Lakandon. Another offering is also intriguing because it closely resembles copal figures made by the Lakandon and described by Tozzer (1907).[39] Similar figures are also reported on the sculpture at Chichén Itzá (Maudslay 1889-1902, III:pl. 51, as cited in Coggins and Shane 1984:132, Fig. 157).[40]

Modern distribution of resin-bearing tree species in relation to Maya archaeological sites

Bartlett (1935b) was the first to begin botanical collection and documentation of the flora of the Maya lowlands and was soon followed by Lundell (e.g., 1937, 1938, 1940), who (Lundell 1939, 1961) suggested that the distribution of certain tree species (e.g., ramón or *Brosimum alicastrum*, Moraceae; *Pinus caribaea*, Pinaceae) in archaeological sites (e.g., Tikal) was the result of ancient Maya cultivation practices. Thus began a long discussion of the effect of human activities on rainforest tree species distribution and community structure in the Maya lowlands, and whose issues remain unresolved.

The distribution of resin-producing tree species in present-day southern Mexico, Guatemala, Belize, El Salvador, and Honduras is intriguing. Is the current distribution of certain tree species a reflection of prehispanic Maya anthropogenic activities or ecological features of abandoned cityscapes? Folan *et al.*(1979) argue that the Maya elite, in Classic and pre-Classic times (prior to A. D. 900, approximately), cultivated economically important trees (e.g., *Protium copal*) and

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[39] At Tikal (Guatemala), Lundell (1982:76) excavated an archaeological resin specimen embedded with a charred mass of seeds.
[40] Lounsbury (Lounsbury 1973) posited a reading of a Maya glyph component based, in part, upon Tozzer's (1907) description and drawing of Lakandon *xikal* but Porter (n.d.) challenges Lounsbury's reading.

controlled the distribution and trade of fruit, fiber, bark, and resin products in the city centers, resulting in the high frequency of certain economically important species found at these sites today. Lambert and Arnason (1982:298) reported *Protium copal* as one of six important species growing on tall structures within Mayan ruins. They also argue that in contrast to an economic relation between presence of tree species and cultivation by ancient Maya (cf. Folan *et al.* 1979), the ecological opportunities provided by the thin, well-draining, soils atop old ruins, ample supplies of exchangeable Ca and Mg, and a high pH, would result in a flora reflective of species competition and selection over time. Until more data is gathered and analyzed at a number of Maya archaeological sites, the question is likely to remain unresolved.

The presence of incense in Maya culture since Contact: Continuity or discontinuity?

Resins are clearly significant natural substances in Maya culture and ritual traditions. How did Maya beliefs about incense, particularly, escape the notice of the Spanish conquistadores and priests? Has the meaning and use of copal remained stable and uninterrupted from the Colonial period to the present? After the conquest of Central Mexico, the Spaniards proceeded to campaign against all native "idolatries" throughout Mesoamerica, by banning the worship of wooden effigies, human sacrifice, and the ancient calendrical system, and other major cultural practices. A long period of conquest and conversion to Catholicism began. Curiously, however, copal was not outlawed by the Spaniards, perhaps because of the long-standing use of incense in the Roman Catholic Church. By not eradicating the use of incense, the Spanish inadvertently permitted the continuation of traditional Maya religious concepts and practices. I suspect that the religiously fervent Spanish perceived the native use of incense as parallel to their own, not understanding that to the Maya, multiple layers of meaning and function were embodied in its nature—the use of incense overlapped between the two distinct cultures, but did not necessarily overlap in meaning.

Modern use of natural resinous substances, and their functions in modern Maya ritual and medicine, and comparison to what is known of copal in colonial Maya societies, reveals some striking continuity through time. What role has incense played in the subsequent development of indigenous Maya culture? Did colonial Maya using copal at the time of contact, and after, "take advantage" of the parallel—but dissimilar— item in their oppressor's strict religious practices? Or did the similarity help the Maya to adapt to the doctrinal changes imposed upon them by the Catholic Church and to retain some of their most fundamental religious convictions? The first statement implies some degree of cultural subversion; a model I would hesitate to support. The second connotes a more indirect and unconscious thought system where incense "fit into" Spanish doctrine and where the Maya themselves may have been unaware of the differences in the two culture's use of incense.

Barbara Tedlock's *Time and the Highland Maya* (B. Tedlock 1992) presents a stimulating discussion of the syncretic theory, a topic hotly debated among New World scholars. The term is used to describe "combinations of pre-Hispanic and post-Hispanic elements." Tedlock suggests that "the exact sources of a particular combination [of ritual and religious beliefs and practices] may perhaps become 'unconscious'—or better, unknown—with the passage of time, but the creation of a combination has probably always been an intentional process..." Carlsen and Prechtel (Carlsen 1997:47-67), in their discussion of community in Santiago Atitlán, Guatemala, provide a cogent review of the arguments and concepts advanced by those arguing against a strong or penetrating indigenous role in subsequent development of colonial Maya society, and for those theories which postulate a continuity between pre-Columbian and modern Maya cultures, at least in regard to certain features, especially cosmological-religious and social. Although a thorough discussion of these arguments is beyond the focus of this study, I tend to agree with Farriss' (1984:8, as cited in Carlsen 1997) statement made in reference to lowland Maya:

> It is not the preservation of an unmodified cultural system under a veneer of Spanish customs, but the preservation of a central core of concepts and principles, serving as a framework within which modifications could be made and providing a distinctive shape to the new patterns that emerged.

Copal can indeed be thought of simply as incense, as in the traditional Catholic mass, or it can be embellished with far more meaning and function as we have seen. Undoubtedly, some Spaniards or others may have recognized that the use of incense in the strange mix of Catholic and pre-Hispanic religious rites seemed to possess another set of qualities, as payment to the pantheon, or as a portal to the ancestors. The prevalence of copal in traditional medicinal treatment today outlasted the Spanish flirtation with New World resins, and their products, through the sixteenth-century to the present. I think there is fairly strong evidence that the Maya's fundamental attitudes toward, and utilization of, copal in their lives, surpasses those attached to Latino incense use. The burning of copal goes at least one step farther than today's modern use of incense as air freshener: copal transforms an earthly substance into a divine food and transformative force and into a sacrificial offering. This phenomenon closely resembles that image with which many of us are familiar: that of Christ offering wine and bread as his body and blood, but Maya ritual behavior predates the arrival of the Spaniards and Catholicism.

Conclusions

Several major investigative questions have been pursued in this section of the study. 1) What uses are made of plant resins in modern Maya society? 2) What are the reported taxonomic sources of plant resins collected, used, and sold by the Maya? 3) How are resins collected and processed? 4) What are their roles in local or regional economies? 5) What are the functions, roles, and symbolism of resins as incense and medicine in traditional Maya society?

It was determined that the primary uses of resins by the Maya are as ritual items and as medicines. Ascertaining the functions, roles, and symbolism of resins as such in traditional Maya society poses an exciting challenge and necessitates comprehension of at least some of the principal features of Maya cultural traditions. Referring to Maya perceptions of the natural world, medicine, and cosmology, deepens our comprehension of the place plant resins hold in traditional culture.

The roles of resinous products in local or regional economies is significant. Yield values for twenty thousand trees on one Lanquín, Alta Verapaz, property, based upon the landowner's personal estimates were calculated. Average annual production yields of copal incense resins in Lanquín have every indication of being high, and if the social and economic relationships between land owner and tenant-collector are understood correctly, then a very good profit and cash source is potentially available to both. Incidentally, the social relationship between landowner and tenant farmer bears some striking similarity to the reciprocal relationship between gods and humans. The Lanquiñeros who collect copal *pom* resins may perceive the former relationship as one of usufruct, where one enjoys the right a of thing which belongs to another and of deriving from it all the profit or benefit it may produce, provided it be without altering or damaging the substance of the thing. In this case, the "thing" is the landowner's resources, which are, presumably, given by the gods. A usufruct relationship harkens back, too, to the ceremonial language delivered by the Maya during rituals, and payment is made to the gods in return for protection of crops and family, but in my mind, the ceremonial prayers lack an sense of entitlement that the quoted definition implies. The correlation between the two relationships may not be strong or significant but they are useful to bear in mind for the present.

To many in the Maya world, ritual events and ceremonies establish a spatiotemporal link between the supernatural and telluric worlds. Both the ritual itself and the sacred site where it is held, in the milpa, at cave entrances, natural springs, or on mountains tops, act as portals between the levels of the Maya cosmos. Ancestral shrines at which the K'iche' make offerings and prayers are conceived of as portals, or thresholds, between the realms of the cosmos (B. Tedlock 1992:71). Communication with supernatural forces depend on powers and abilities of shamans and others to invoke the divine presence by prayer, offerings, sacrifice, and libations, and other divinatory techniques. Malevolent spirits and deities are banished by the burning of copal, and a space is sanctified and prepared for ceremonial use. It is the moment in which, for the Maya, and many other American indigenous people, the barriers between the human and divine worlds become invisible and contact with creationary forces occurs. It is a moment and experience largely unknown in industrial Western nations, except for rare epiphanal moments. Indeed, for much of Western Europe and the United States, incense is seen only during Catholic or Episcopal masses, and few substances that can render such an effect come to mind, besides hallucinogens.

Copal is a natural substance with multivalent meanings. When copal is scrutinized for its historical significance and functions from an indigenous viewpoint, a complex cultural paradigm emerges. Copal is used in specific instances and events in modern Maya life. It is commonly used when a request is made to the gods or deities (whether accompanied by a sacrifice or not), during agricultural or rain rituals, or in healing rituals. The use of copal relates to long-standing cosmological beliefs of the Maya, in which a series of reciprocal relationships and processes were established and maintained with natural forces in the universe. I argue that the burning of copal incense by humans helps to activate and initiate dialogue (relationships) and transformative processes (spatiotemporal processes) with the diverse body of indigenous gods and ancestors, spirits associated with nature, and forces of destiny (who are in power). In ancient Maya society, a crucial focal point of such interactions was the ruler, for it was he who had the ability and power to initiate this dialogue, and he acted as a conduit for both human and divine forces. By displaying his ability to invoke the presence of the gods, and to successfully petition them for their beneficence, the ruler and his priests wielded enormous divine power. Ritual actions, like human and auto-sacrifice, the burning of copal and candles, and the consumption of maize, also ensured that the movement of destruction and creation, and thus the Maya cosmos, would be perpetuated and maintained. Modern Maya society has adapted and evolved in relation to its natural and social surroundings, and is distinct from its pre-Columbian and Colonial predecessors. The Maya no longer make human sacrifices to propitiate the gods, there is no overt internecine warfare between indigenous groups,[41] and there are no longer kings, but national and regional political institutions governing society, yet strong ties to communities and lineages remain. Certain forms of the ancient calendric system survive today, and modern narratives, such as stories, myths, domestic conversations and teachings in which copal is present,

[41] This is somewhat overstated, because of the recent nefarious civil war in Guatemala and the current relations between the Zapatistas and the central Mexican government. I mean to emphasize that battles designed to "collect" warriors and people for later sacrifice, such as the preColonial "flower wars," are no longer planned and implemented.

suggest that some religious principles and systems of the earlier period are retained, or at least conserved in similar forms. Among modern Maya the role of the divine potentate is served by village and family elders, curers (curanderos), or shamans. I believe copal continues to represent and embody multiple functions intrinsic to Maya cognitive thought and processes. The burning of incense is recognized and perceived as a symbol of the natural forces at work in the universe, as one of several communication conduits based on plant substances, and as a substance transformed into a sustaining food for the gods, and as a sanctifying ritual substance.

I believe also that there is a large enough body of evidence to permit us to consider that copal may a substitute for the human body, as evidenced by the feeding of the Lakandon god pots, the human effigies molded by them for *xikal*, and the accompanying chant recorded by Tozzer (Tozzer 1978:178-179). The odor of blood is known to have been pleasurable to the gods (witness the Lords of the Underworld in the *Popol Wuj*). Copal may serve as a substitute for blood, because it shares the same animating properties as blood, in all animate beings. The Ch'ortí provide offerings of copal "pesos" as payment. Copal, or *pom* is sometimes called the "blood" of the tree (*kik'* '). Freidel *et al.* suggest that resin secretions are composed of and constitute *itz*, the stuff of life. Since iconographic sources, like the Maya codices, and colonial Spanish and indigenous documents support the long use of copal as incense, medicine, and as an item of collection and trade, for more than a millenia (Linda Schele, pers. comm.), and more likely, longer, whether the Q'eqchi' Maya or others elsewhere substitute copal *pom* for blood, or whether they continue to practice or believe in blood sacrifice may be moot at this point. Copal is seen as an animating substance in a physical sense, it is perceived as plant blood, and feeds the gods. It is a natural substance animating the currency between the worlds and is in a dynamic flow from one to the other; without this flow, the fruitful relationship between humans and gods could not exist.

To the Maya, copal is a transformative agent, and a substance deeply connected to super- and natural processes,whose true importance is manifested in cosmo-ritual events. It is a means by which the social relationships between humans and gods can be equalized and confirmed. Resins, as a general form, finds great utility in traditional medicine. The presence and forms of resins in traditional indigenous societies of the Americas should not be underestimated or ignored. Tremendous insights into these cultures can be derived by a number of disciplinary approaches and further appreciation of those cultures is encouraged.

VI. Conclusions: The Ethnobotany of Plant Resins in the Maya Cultural Region

COPAL AS A SACRED SUBSTANCE IN MAYA CULTURES

The Maya of southern Mexico and Central America have deep ties to their ancestors, deities, and gods, and to the natural, organic environment in which they live. Natural plant exudates play a significant role in both social (between humans and the supernatural) and biological (physical environment) realms, as incense and as medicine. Plant exudates are perceived to possess properties analogous to blood, and copal incense is a specific product which is offered as a substitute for blood or the human body. According to the data presented here both the ritual act of burning copal and the exudate substance itself, are sacred. Copal incense invokes, propitiates, and nourishes the deities who possess a somewhat temperamental hold over the well-being of humans. Copal as medicine, as ointment or smoke, relieves the body of harmful spirits, fever, and respiratory problems, and gladdens and strengthens the soul of human and spirit alike. The function and significance of copal, primarily as incense, becomes clearer if one considers the web of social relationships that are generated and maintained by its collection and its ritual uses.

Collection of copal relies, in part, upon good social relations between the Maya and their natural environment, inhabited as it is with deities and souls of plants, animals. The act of burning copal, accompanied by "language for rendering holy" (Gossen 1974) induces two primary actions whose effects have profound consequences in the Maya world view. First, copal smoke invokes the presence of deities, ancestors, and gods, and assures that the relationship between these entities and humans is reinforced and maintained. The second effect is the initiation of a series of transformative processes which appear to characterize Maya religious and . cosmological beliefs. Within each of these events, copal plays a critical role: it is offered as a substitute for human blood or "money" (still analogous to blood) and as a substance which nourishes the tutelary forces in the Maya world. The theory that copal is perceived as a symbolic or literal analog of blood, and that it is a sacred substance capable of initiating transformation, and which is, by extension, an effective medicine for a range of illnesses, is substantiated by the ethnographic, linguistic, and folklore data, and by field data collected by the author. The concepts associated with copal are widespread in Maya society; I have presented only five major Maya ethnicities here and there are many more which share numerous aspects of the beliefs discussed here. I also maintain that the knowledge of the properties of copal are standard in the Maya world view: that there is a set of "core knowledge" shared by the different Maya groups discussed here, and a set of "alternative knowledge," in which variations or heterogeneity of concepts is manifested.

The use of copal in regulating relationships between humans, deities, gods and ancestors

Table 1 below presents the roles of copal in the maintenance of the supernatural, human, and natural worlds. In the relationship between the Maya and their deities, gods, and ancestors, copal serves as a debt-payment to these beings for continued benevolence, in the form of currency or offerings and as a nourishing substance in the form of heat, smoke, light, aroma, substances which the supernatural requires to exist. Copal smoke is used to invoke and propitiate these beings, and to establish and purify ritual space.

In the relations between humans, copal also plays an important role: in Lanquín, Guatemala, there is an economic benefit to both owner of resin-bearing trees and to the indigenous collectors, a kind of usufruct exchange in which both parties stand to have considerable profits and there is only one primary resin source. In the western highlands of Guatemala a more complicated trade and commodity exchange exists between collector, processor, and seller of a wide range of plant exudate products. In the realm of medicine the shaman, healer, or community elders combat illness with the aid of copal and copal smoke (addressed more fully below). Illnesses familiar to the Western world, fever and respiratory problems, and those unfamiliar, susto, soul loss, and supernatural displeasure, are assuaged by copal.

In the natural world, according to the data, the collection of tree resins is perceived as collection of the tree's blood, an animating substance. Collection requires reverence for the soul of the tree and sometimes preparatory fasting is required of the collector. In the agricultural world of the Maya farmer, copal "pesos" serves as payment to natural forces, and among the Ch'ortí, copal may be considered one of the progenitors of maize. Finally, there seems to be some evidence that some Maya perceive a difference between the "cultivated" world and the "wild," in distinctions between incense types made by the Tzotzil. I also feel it important to state that I am not suggesting that the Maya perceive these realms as three distinct entities. I think, rather, that such distinctions are few and that these realms segue into each other, and are woven together tightly, being all of a piece.

Table 6.1 How copal functions in the domain of the supernatural, of humans, and the natural environment

Supernatural world	***Human world***	***Natural world***
Debt-payment	Economic: a) Usufruct relationship with resource owners b) Cash-resource exchange system	Respect for tree's animatedness, soul
Currency	Medicinal: relationship with shaman, healer, elder. Illnesses recognized by Western culture and those considered "cultural," e.g., susto	Collection of tree's blood
Feeding/nourishing substance. Properties of heat, light, smoke, aroma, sound		Fertility/regeneration, birth of maize
Ritual language		"Cultivated world" in relation to "wild world" e.g, milpa in relation to forest
Invocation		
Propitiation		
Purification		

Copal as initiator of transformative processes

Copal is a powerful substance utilized and revered by the Maya for its transformative properties. Table 2 lists the properties I believe are suggested by the ethnographic and field data. A primary orthodox belief is in the ability of copal smoke to establish ritual time and space and to effectively serve as a communication conduit between gods and humanity. Once invoked, there is dialogue between the two parties may commence. Copal transfigures inanimate objects into the animate; transforms itself into blood, into tortillas, into money, and into nourishing heat, light, aroma, and sound; into essences which the divine beings can consume. As suggested by the *Popul Wuj*, plant exudates can serve as substitutes for human hearts in sacrificial acts. The Ch'ortí data suggest that maize gruel and copal are the progenitors of maize, signaling properties of fertility and regeneration. Souls can be recovered or strengthened by copal smoke and evil spirits banished. Copal is believed effective in counteracting illness and magic, and is again used as a substitute for the human body.

The ability of copal to initiate communication with the divine and it's ability to transform objects into divine essences demonstrates the nature of this sacred plant substance. There is strong evidence as well that at least some Maya perceive it as endowed with fertility powers.

Table 6.2 Transformative properties initiated by the burning of copal

Invocation of sacred time and space, dialogue with supernatural
Transfiguration of exudate into substitute for human blood and heart into food, "money," tortillas, heat, light, smoke, aroma, all nourishment for divine entities
Maize gruel and copal into progenitors of maize, strongly associated with fertility and regeneration
Soul recovery and regeneration
Banishment of evil spirits
Counteraction of illness and magic, copal as substitute for human body
Animation of objects

Sources of evidence for copal as an analogue of blood and as a sacred substance

The evidence that copal is an analogue of blood and a sacred substance comes from four sources: ethnographic literature and field data collected by the author, from linguistics, and from Maya folklore. I shall briefly consider specific pieces of testimony for each category of evidence. Evidence for the significance of copal in Maya ritual and religious beliefs is apparent in the prominence of plant exudates in the ethnographic literature. For example, the earliest Spanish chronicles, e.g., Landa (Tozzer 1941), the *Chilam Balams* (Roys 1933, Edmonson 1982, 1986), illustrate the use of incense in little-understood Maya rituals. In the present, such modern practices as the Ch'ortí practice of "paying" for the right to hunt animals, and the "planting" of maize gruel and copal in their milpa to generate the next maize crop, the payment of community officials in the Larraínzar Tzotzil community with resinous woods from a specific plant taxa, and contemporary cave rituals in which copal and candles are offered to the supernaturals as food, demonstrate that copal finds use in many aspects of Maya cosmology and religion. The literature also provides evidence for the supernatural intervention of copal in illness and banishment of "cultural" diseases. Field data support the ethnographic implication that there is a wide diversity of copal types as well as an extensive trade network in the Maya cultural region. Such a trade network was identified in the western highlands of Guatemala, while a small-scale economic system was documented in the eastern portion of the country.

The linguistic data are critical to the development of the theory of copal as a blood analogue and is derived from four main sources: the *Popul Wuj*, the Tzotzil, the Lakandon, and Yukatek Maya vocabularies. For instance, in the *Popul Wuj* (Tedlock 1985), the term given to the red exudate from *Croton sanguifluus* (Euphorbiaceae), is a literal translation of the K'iché word for blood, ***kik'***, which also refers to "gums and resin from trees, in this case the blood-red resin of the cochineal croton" (*Croton sanguifluus*) (Tedlock 1985). Blood Woman's betrayal of her father initiated the substitute of the "blood" of trees instead of the blood or hearts of humans. The ball in the ballgame played by the Hero Twins in the *Popol Wuj* (Tedlock 1985) is made from latex of *Castilla elastica* (Moraceae) and is also called *kik' '*, or "blood." The term *kik' '* is also used by the Lakandon to describe the latex of *Castilla*, from which sacrificial figures are made and offered to the gods. The Tzotzil name for incense, *xch'ich'el* (Breedlove and Laughlin 1993), is also the name given red "saps" or exudates. There is also the term *bek'tal pom*, which describes "flesh incense." The nearby Tzetzal Maya use the term *ch'ich* for blood (Brian Stross, pers. comm.).

Folklore also contributes evidence to the copal-as-blood or sacred substance theory. Once again, the *Popol Wuj* is referred to as it describes the offering of plant exudate-resin to the gods, and as a heart substitute. The Tzotzil stories (Gossen 1974; Vogt 1976; Breedlove and Laughlin 1993) are replete with descriptions of copal as food for saints, as gifts-offerings, and resin as a rabbit trap in the milpa of the creator, and as possessing nourishing qualities. *Nuxi*, one of the ancient ancestors of the Lakandon (McGee 1990), is an immortal human who tends sacred incense trees. Finally, among the early Yukatek sources are numerous references to copal's qualities of heat, light, aroma, and sound, all essences which feed the gods. The provocative statement that copal is "the superodor of Heaven" (Roys 1931, 1976; Tedlock 1985) remains puzzling and unresolved. More research is necessary in order to untangle possible meanings and to avoid erroneous interpretation.

Certain features and properties of copal and plant exudates are shared to a great degree by the Maya ethnic groups considered in this study, and I believe that further investigation into other Maya groups will confirm the model I propose. I propose that there is a set of deeply embedded perceptions shared by the Q'eqchi', Ch'ortí , K'iche', Lakandon, and Tzotzil Maya, which I will call "core knowledge." A smaller body of perceptions I will define as "alternative knowledge," where variations on the properties of copal can be placed:

Core knowledge	**Alternative knowledge**
Food	Susto
Debt-payment	Soul loss and recovery
Petitions	Parasites
Treatment of fever, swelling, infections	Taboo (e.g., *awas* in the Q'eqchi' region) and consequences of irreverence
Rains cycles and crop fertility	Progenitor of maize crop
Invocation and communication with divine pantheon	Rain cycles? Relationship between caves, smoke, and rain

Copal as medicine in the Maya cultural region

Copal's phytochemical properties undoubtedly influenced its incorporation into the Maya *materia medica*. In accordance with Western practices, terpenes and phenolic compounds found in resins used by the Maya, are used as febrifuges, as emmenagogues, and as vulneraries. The treatment of such "cultural" diseases, like susto, soul loss, and possession of the body by evil spirits, is an extension of the perceived metaphysical properties of copal. Numerous species of resin-bearing tree species in the Maya cultural region facilitated its medicinal uses and are these natural resources are still heavily relied upon by many Maya ethnicities today.

As I have demonstrated, plant exudates and copal, specifically, are tied profoundly to a rich body of social, economic, medicinal, and religious practices in traditional Maya culture. This systematic treatment of natural plant exudates in indigenous Maya society is the first of its kind for the New World. I have sought to recruit evidence from the traditionally distinct fields of phytochemistry, plant taxonomy, and ethnography in order to resolve some of the problems identifying taxonomic sources, assessing the medicinal properties of plant exudates, and social perceptions surrounding resins. I have tried to show that resins are not just minor plant products in Maya culture, but are deserving of far greater attention by ethnobotanists and the modern world. I hope to have brought the reader at least a few steps into the Maya world, where the abundance of plant exudates is the "work of god and nature".

Figures

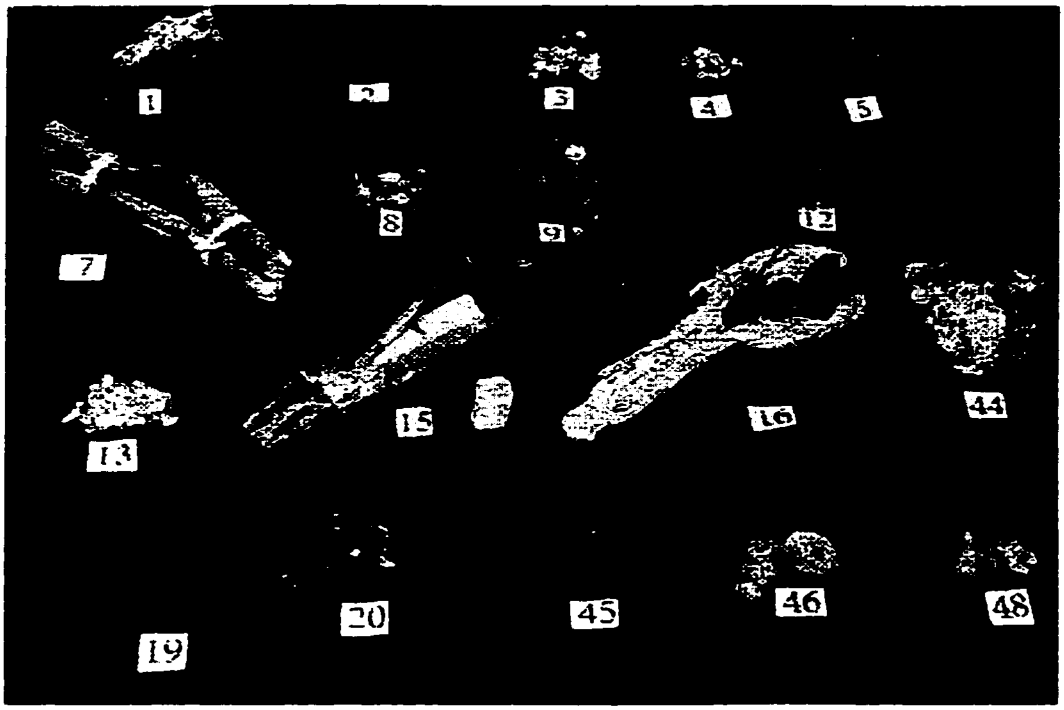
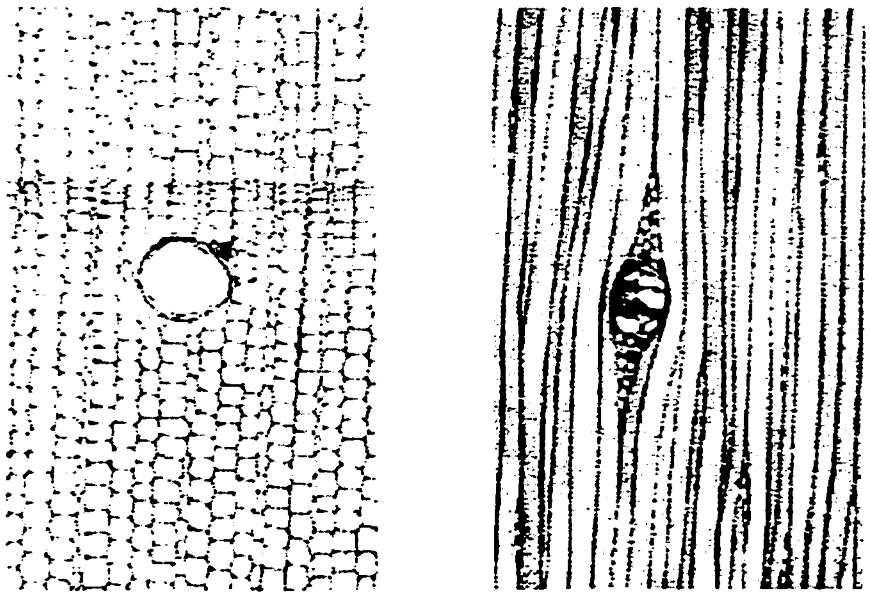
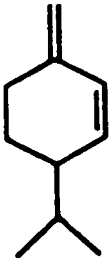


Fig. 1 Selection of plant exudates purchased in indigenous markets in Guatemala with collection numbers (in possession of author)

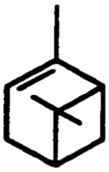


a) b)

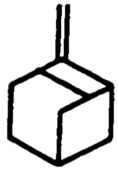
Fig. 2 Example of resin duct in the wood of *Pinus* (Pinaceae) a) Cross section of duct b) Transverse section of resin duct in ray. Courtesy of J. Mauseth



a) *b*-phellandrene



b) *a*-pinene



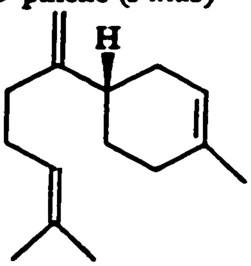
c) *b*-pinene

Monoterpenes

a) *b*-phellandrene (*Pinus*, Pinaceae, and *Myroxylon balsamum* var. *balsamum*, Fabaceae)

b) *a*-pinene (*Pinus* and *Bursera*)

c) *b*-pinene (*Pinus*)

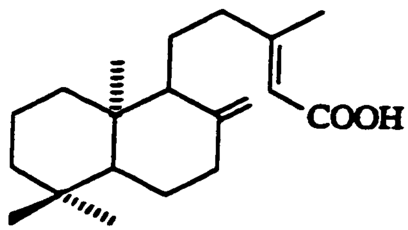


d) *b*-bisabolene

Sesquiterpenes

d) *b*-bisabolene (*Hymenaea*)

Fig. 3 Common mono- and sesquiterpenes and some taxa in which they occur.

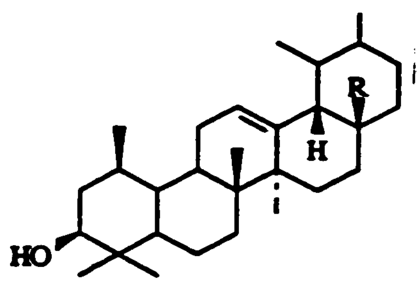


Diterpene acid

a) Copallic acid (*Hymenaea courbaril*)

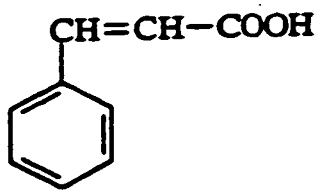
Triterpene acid

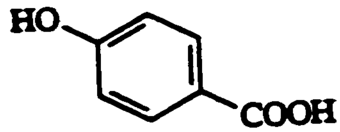
a) *α*-amyrin (Burseraceae)

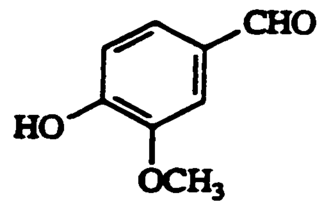


R = CH_3 α-amyrin

Fig. 4 Some common diterpene and triterpene compounds







a) Cinnamic acid b) Hydrobenzoic acid c) Vanillin

Phenolic acids

a) Cinnamic acid (*Myroxylon balsamum* var. *pereirae*, Fabaceae and *Liquidambar styraciflua*, Hamamelidaceae

b) Hydrobenzoic acid (*Myroxylon balsamum* var. *pereirae*)

c) Vanillin (*Myroxylon balsamum* var. *pereirae*, Fabaceae and *Liquidambar styraciflua*, Hamamelidaceae

Fig. 5 Examples of phenolic compounds and taxa in which they occur

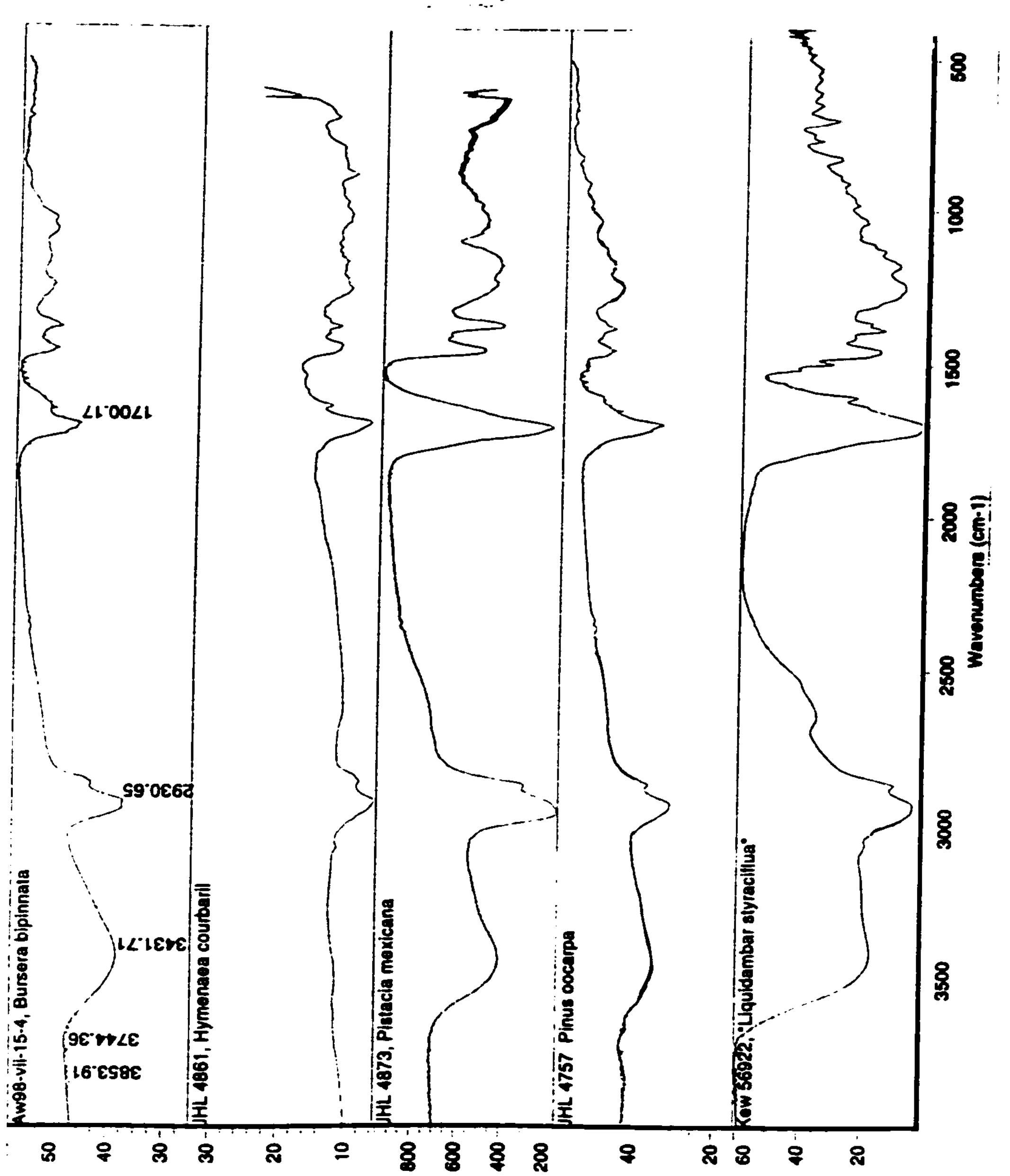


Fig. 6. Spectral "fingerprints" from identified samples representing five different plant families; Burseraceae (*Bursera bipinnata)*, Fabaceae (*Hymenaea courbaril*), Anacardiaceae (*Pistacia mexicana*), Pinaceae (*Pinus oocarpa*), and Hamamelidaceae (*Liquidambar styraciflua*).

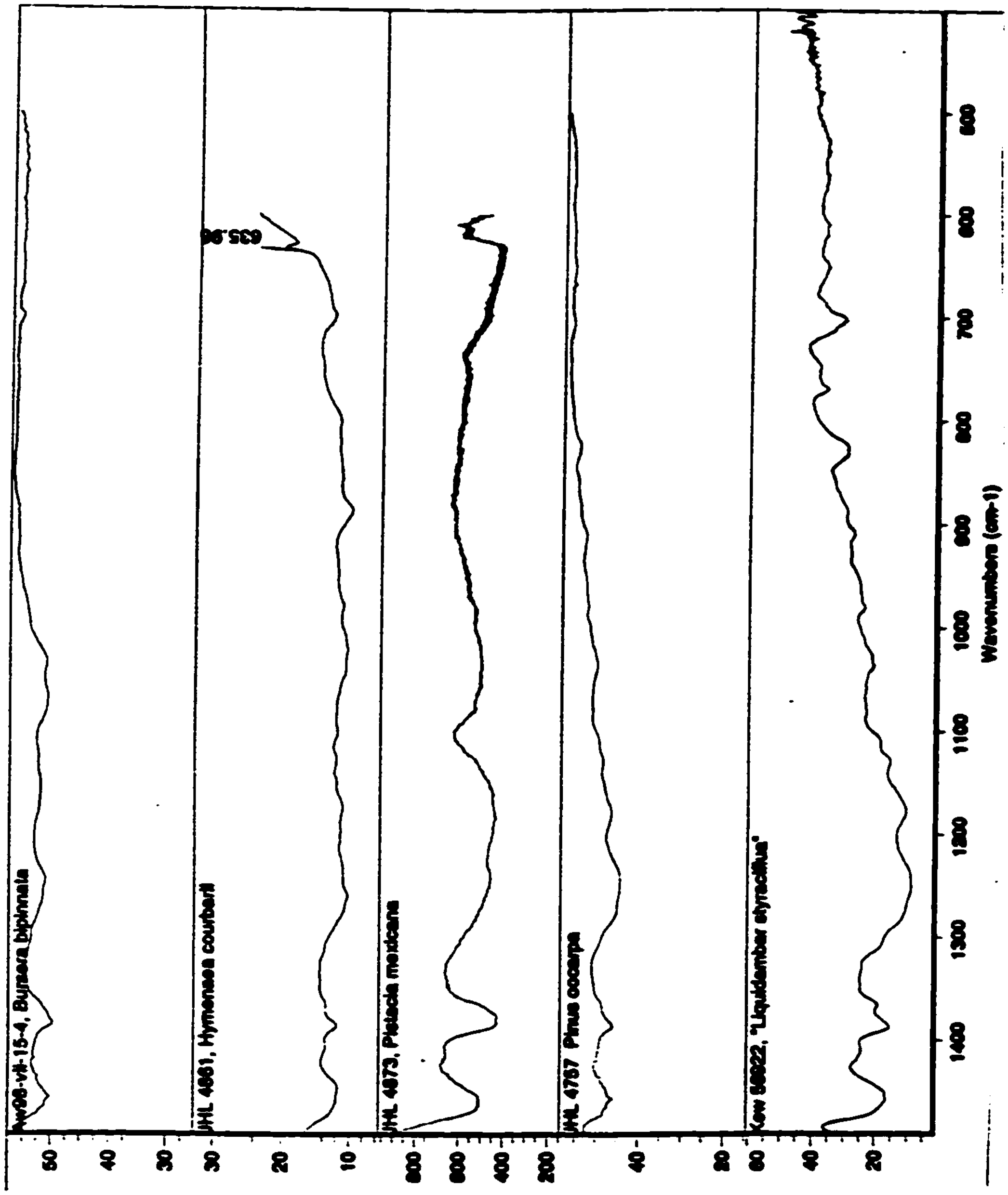


Fig. 7. Upper region of spectral "fingerprints" from identified samples representing five different plant families; Burseraceae (*Bursera bipinnata)*, Fabaceae (*Hymenaea courbaril*), Anacardiaceae (*Pistacia mexicana*), Pinaceae (*Pinus oocarpa*), and Hamamelidaceae (*Liquidambar styraciflua*).

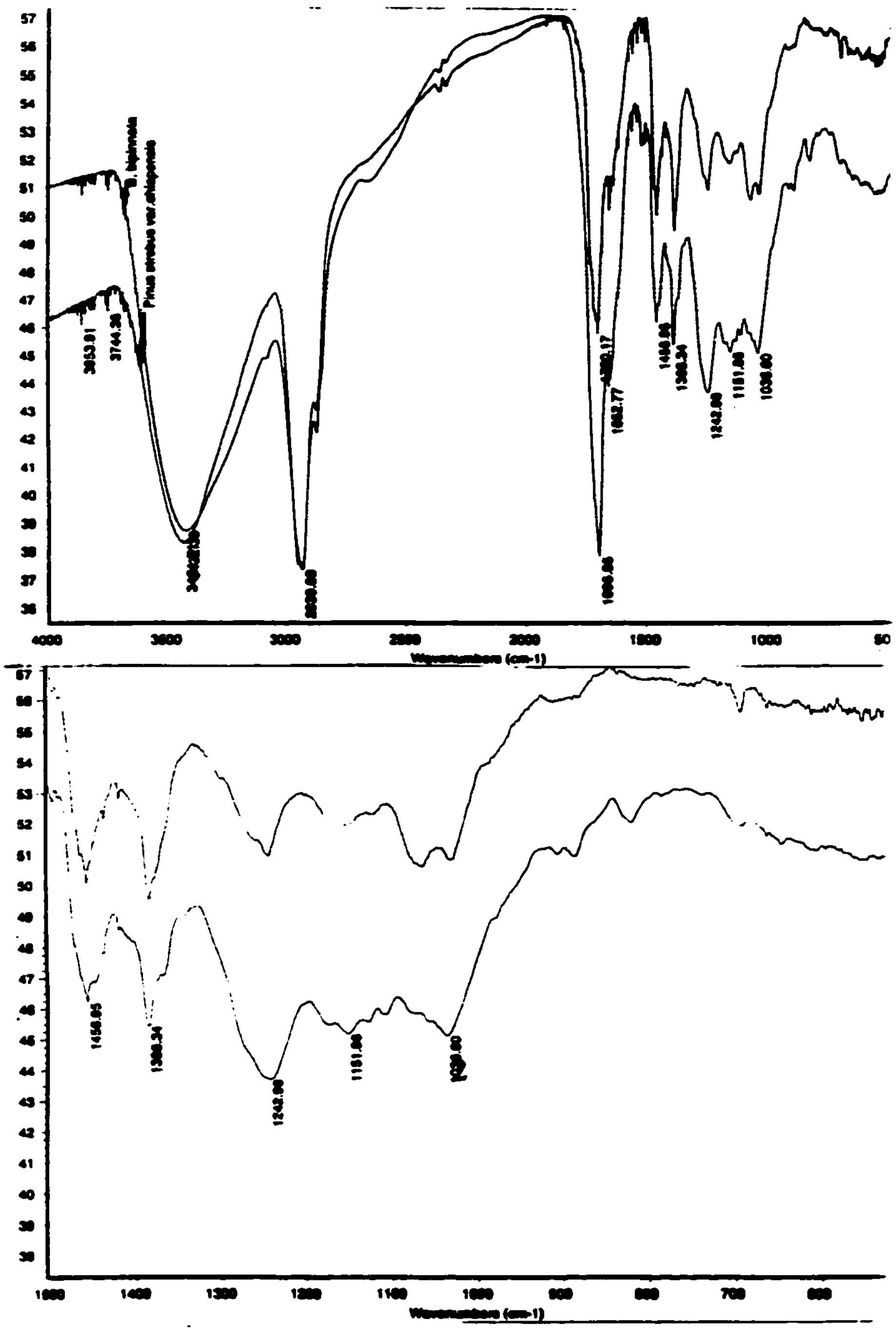
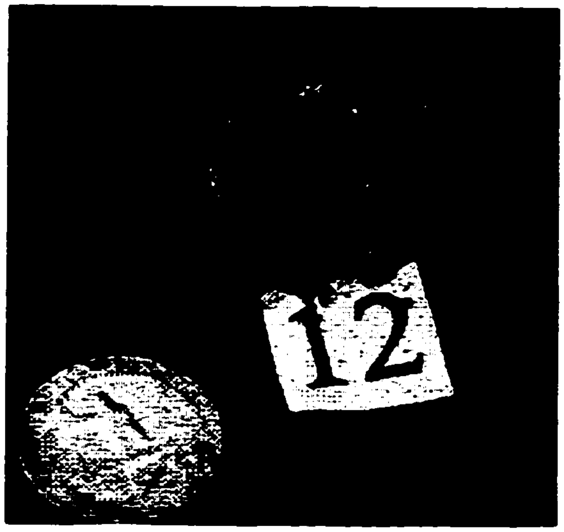
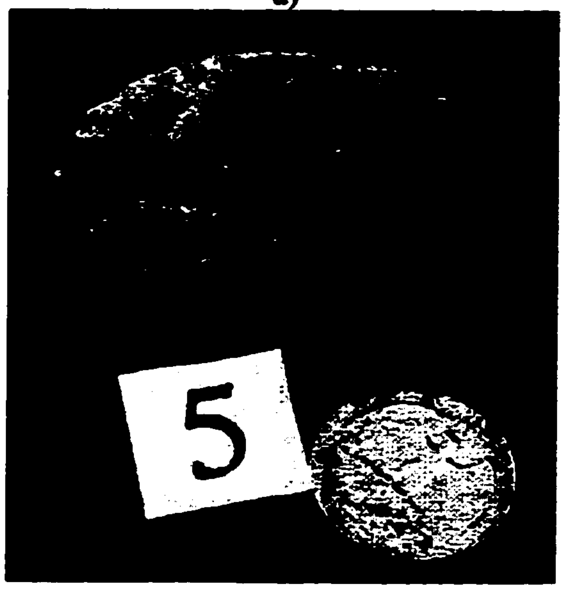


Fig. 8 Comparison of spectra from two distinct taxa, *Bursera bipinnata* (Burseraceae) and *Pinus strobus* var. *chiapensis* (Pinaceae), full spectrum and upper region.



a)



b)

Fig. 9 a) Exudate sample KT12 b) Exudate sample KT5

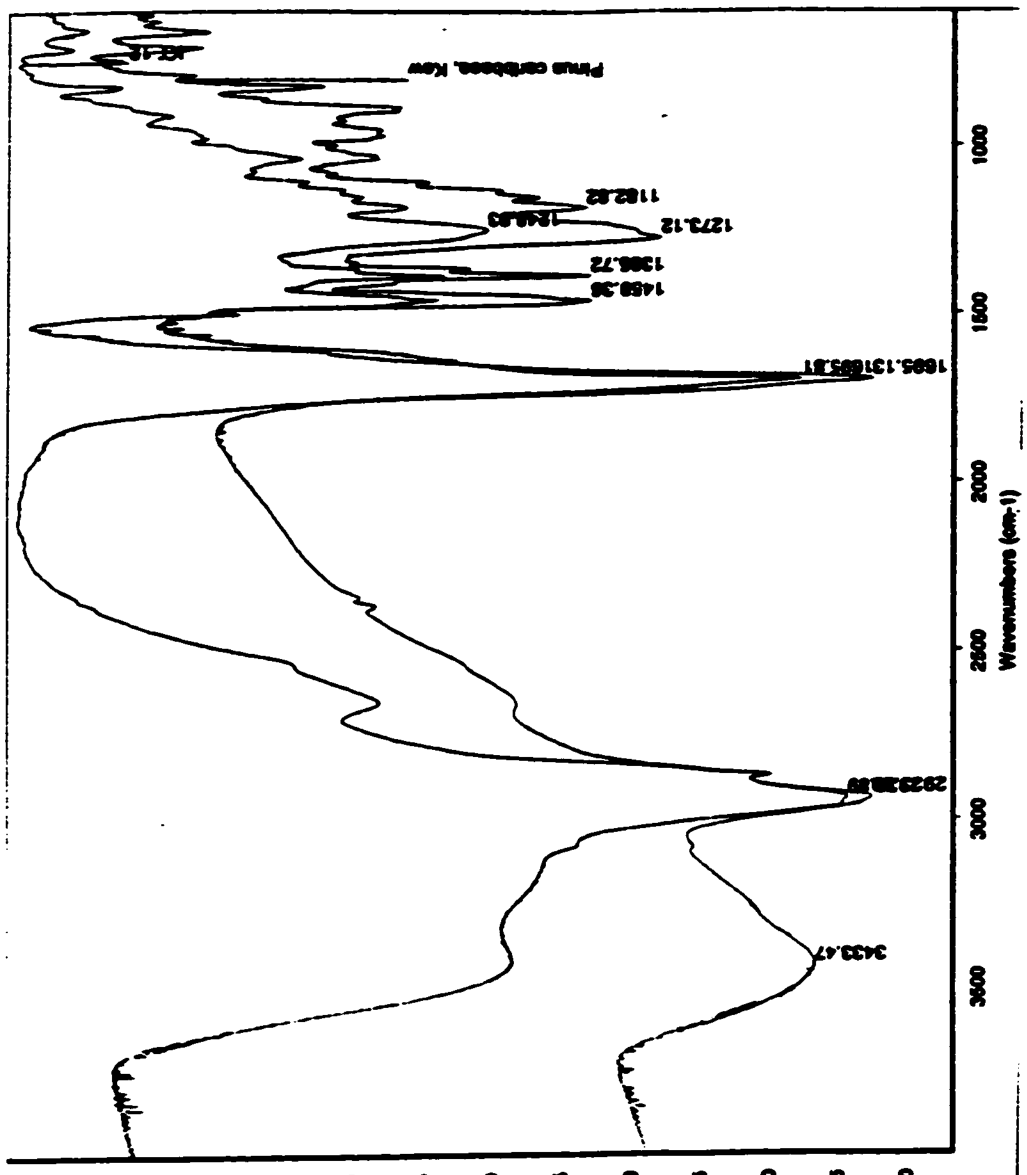


Fig. 10. Spectral comparison of unidentified exudate sample KT 12 and identified sample Kew 27872, *Pinus caribaea*.

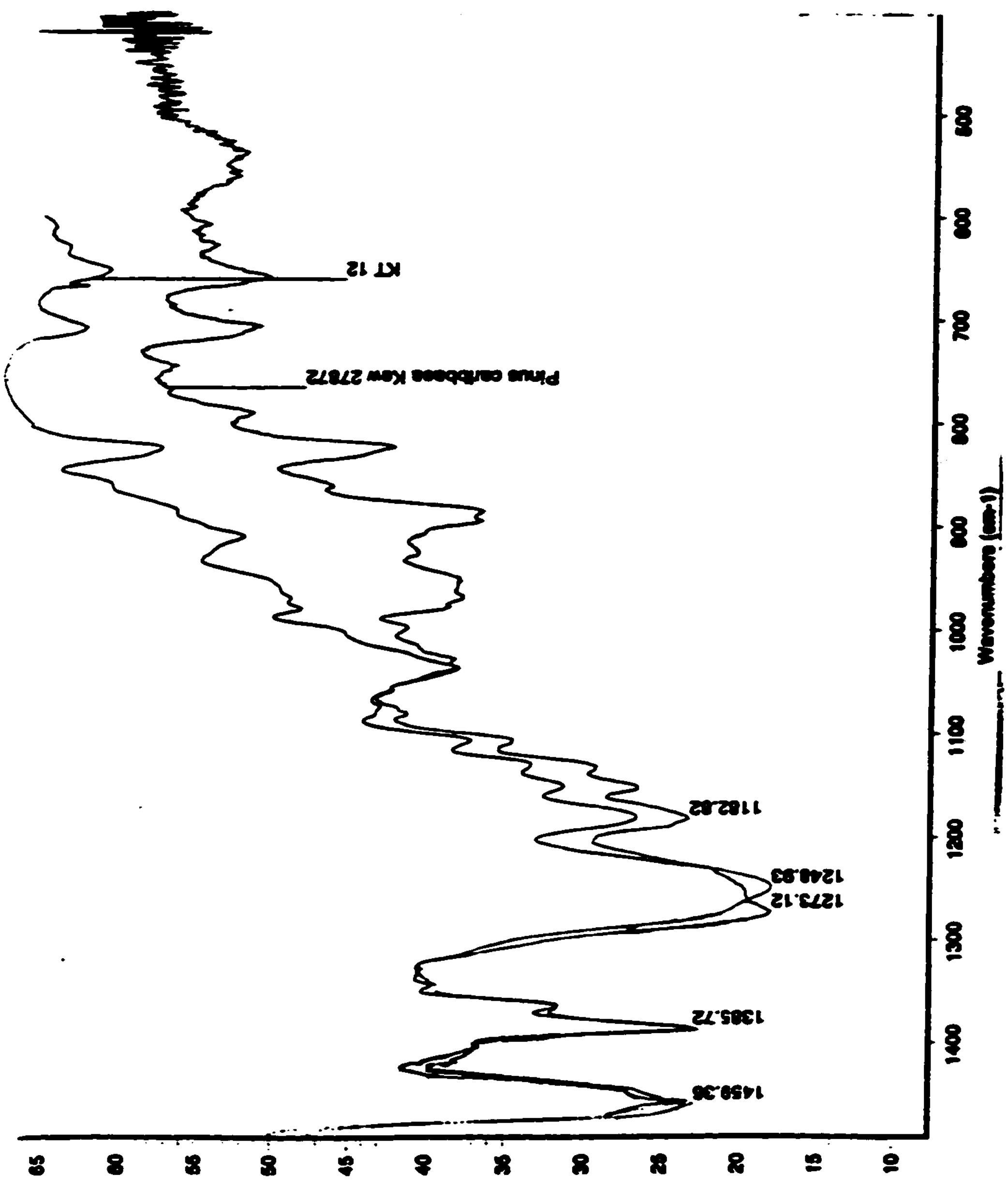


Fig. 11. Upper region, spectral comparison of unidentified exudate sample KT 12 and identified sample Kew 27872, *Pinus caribaea*.

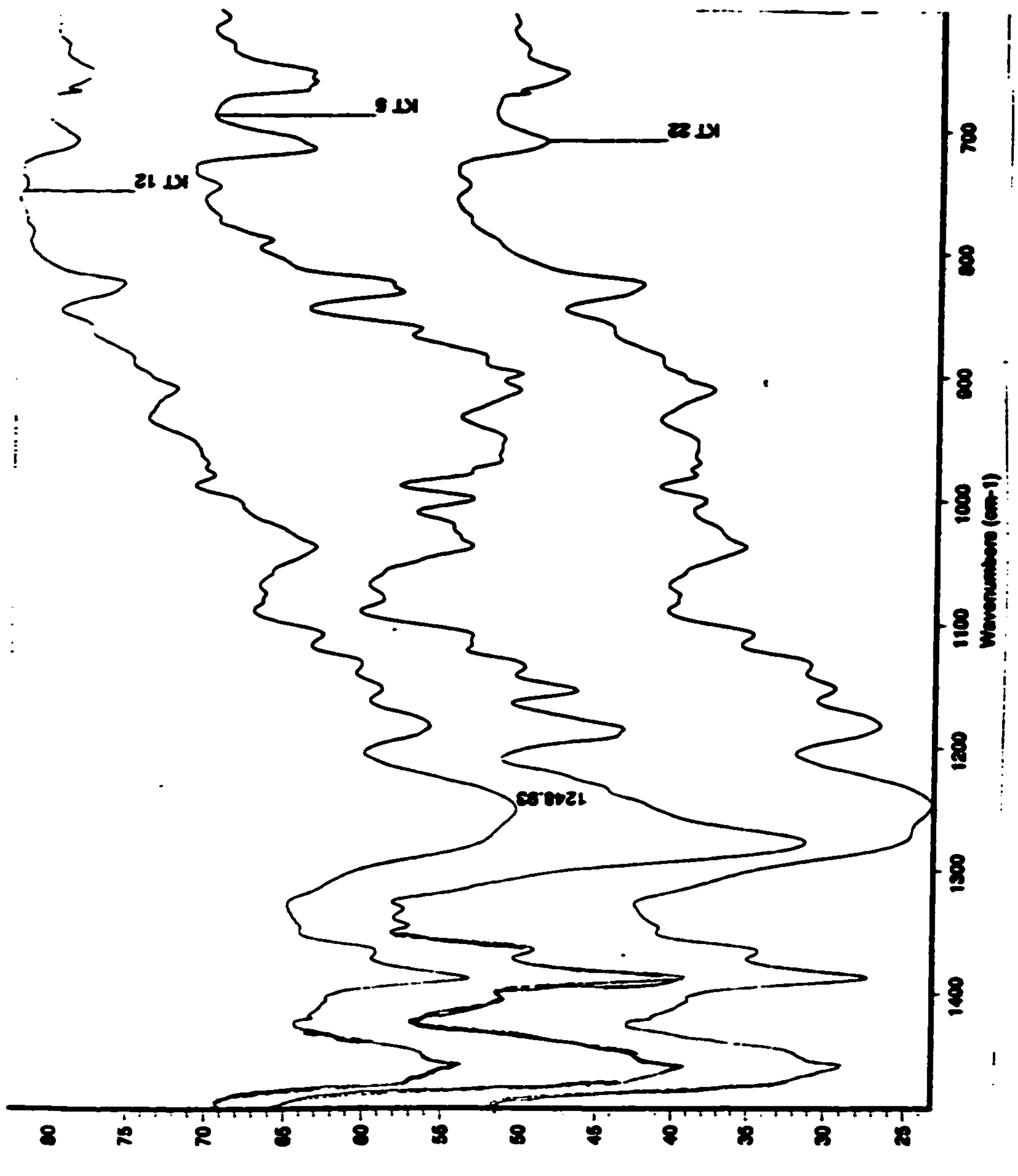


Fig. 12 Upper region, spectral comparison of exudate samples KT 12, KT 5, and KT22.

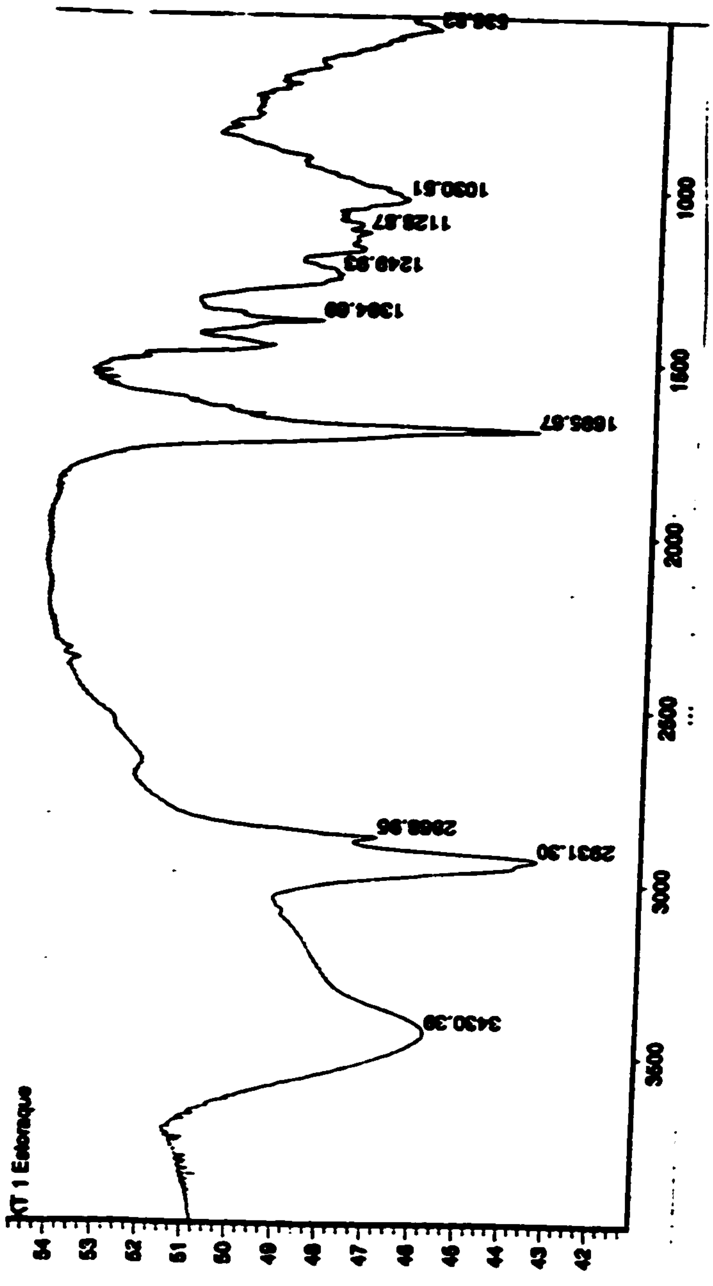


Fig. 13 Spectrum of KT 1.

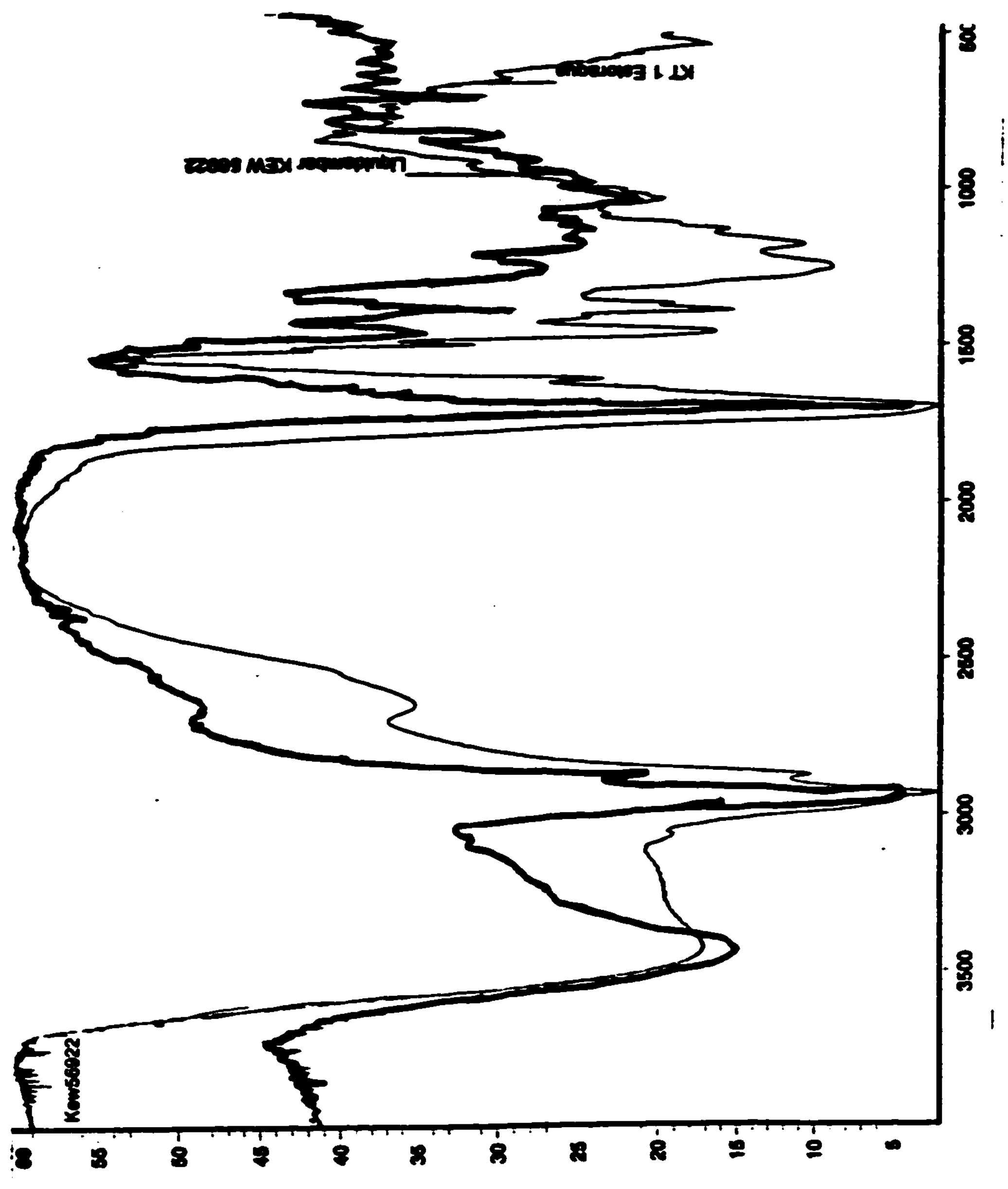


Fig. 14 Spectral comparison of exudate samples KT 1 and *Liquidambar styraciflua* (Kew 56922). Heavy line is *Liquidambar styraciflua* spectrum.

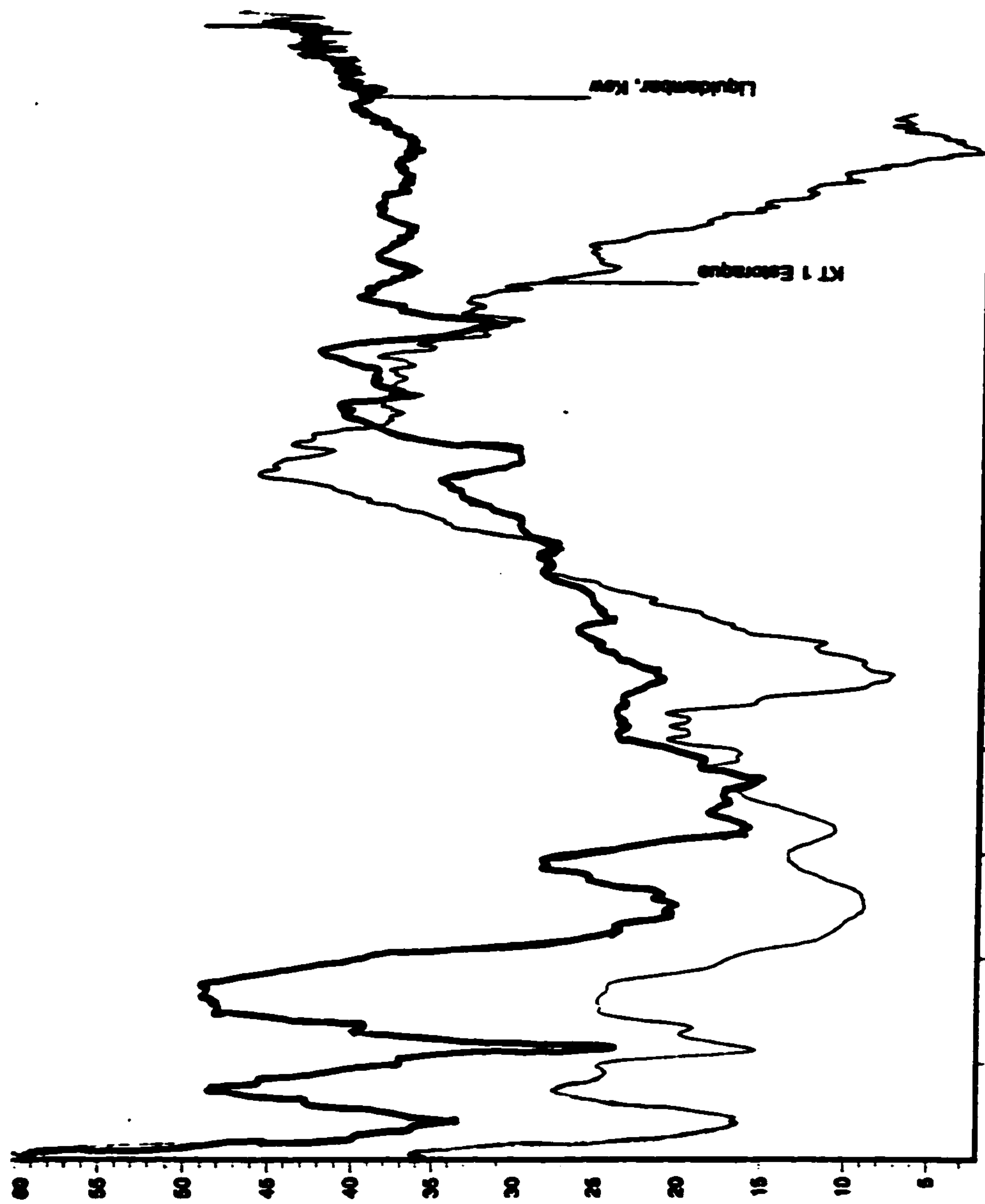


Fig. 15 Upper region, spectral comparison of exudate samples KT 1 and *Liquidambar styraciflua* (Kew 56922). Heavy line is *Liquidambar styraciflua* spectrum.

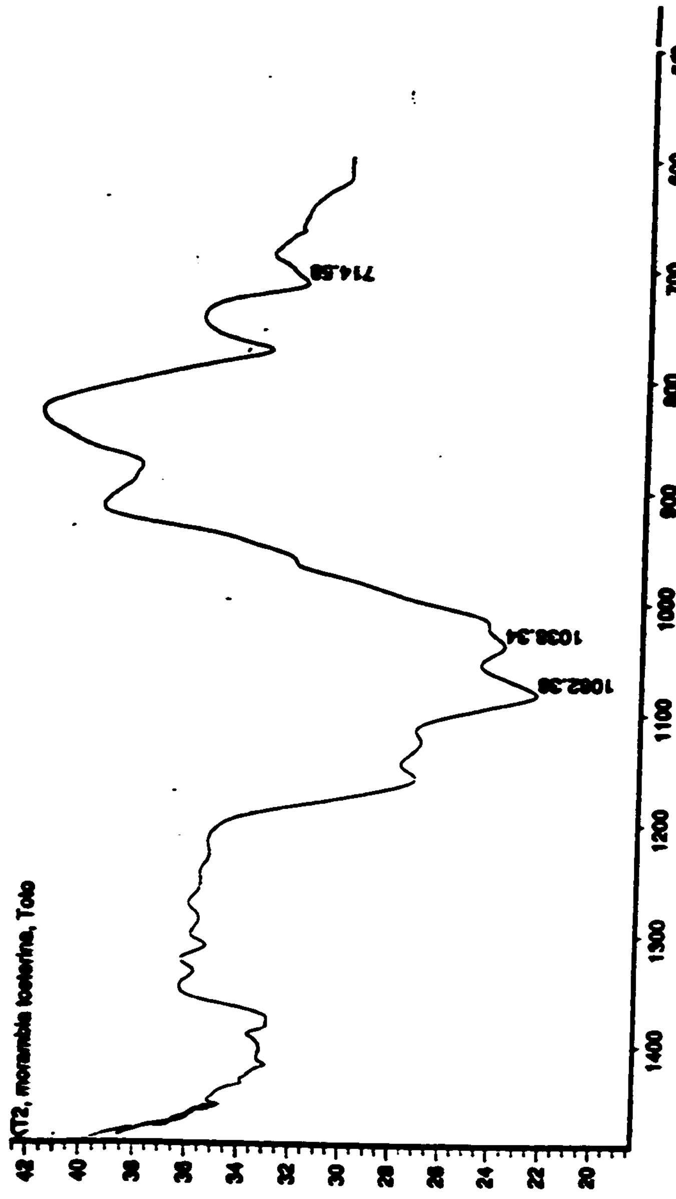


Fig. 16 Spectrum of exudate sample KT2.

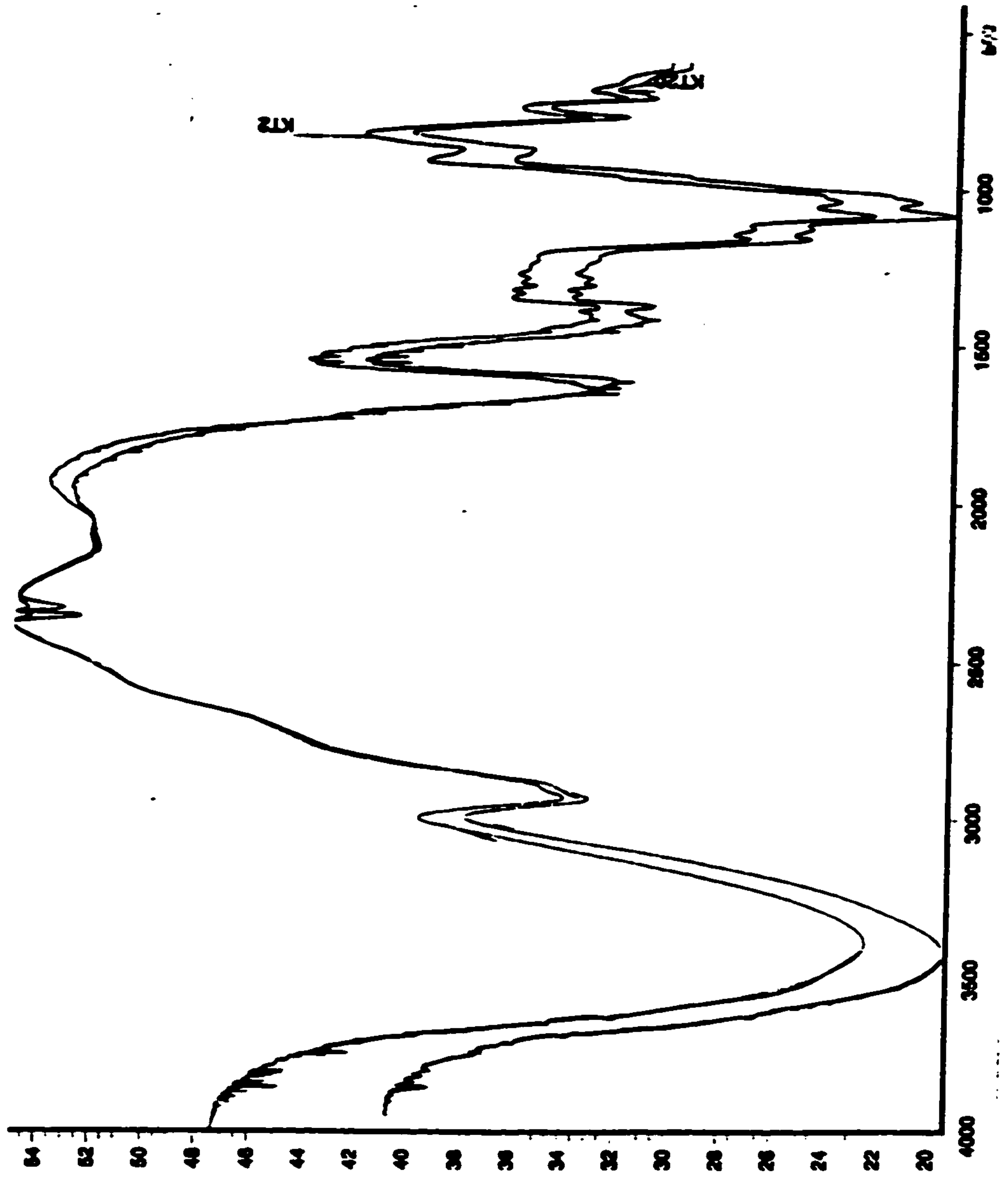


Fig. 17 Spectral comparison of exudate samples KT 2 and KT 20.

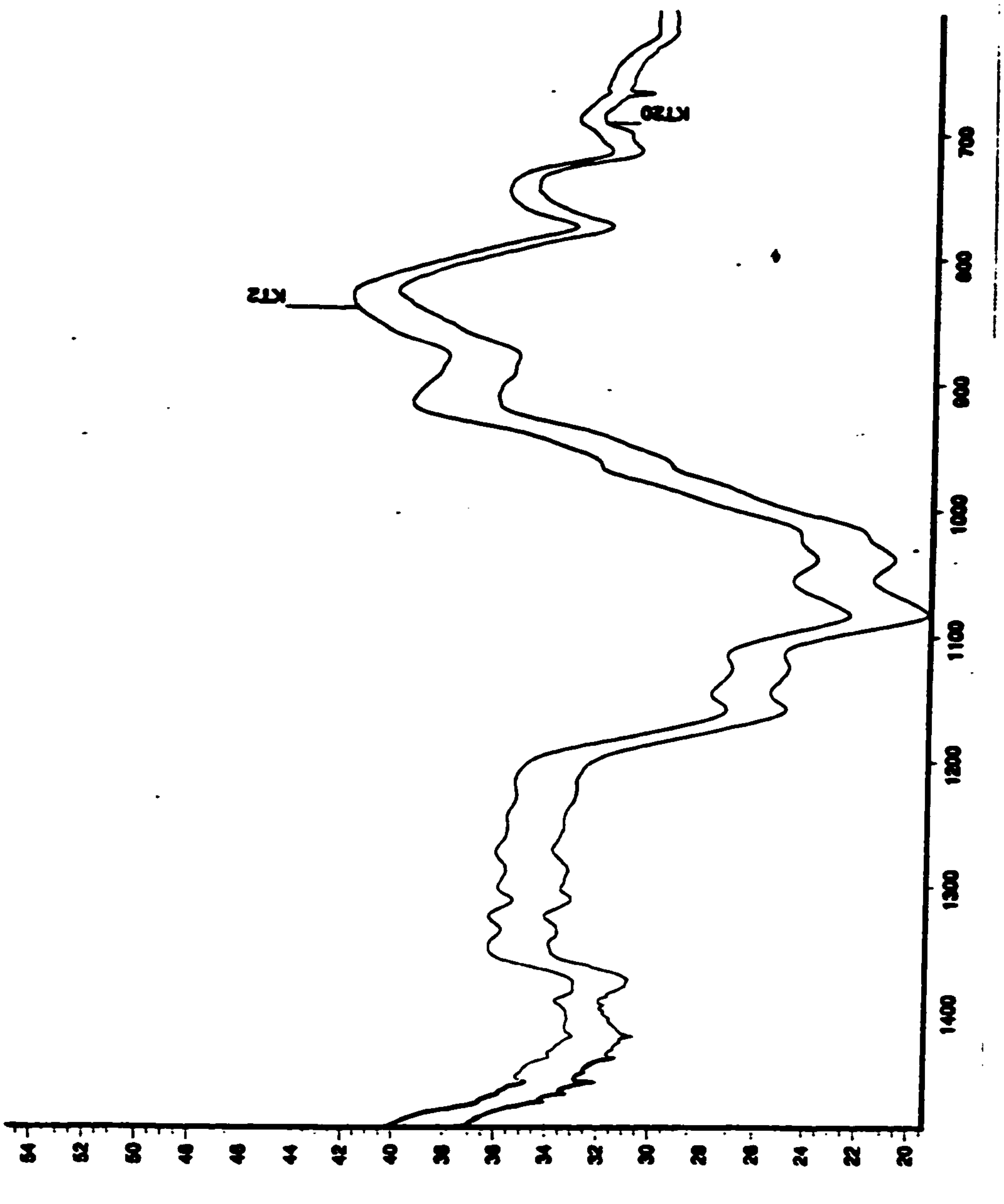


Fig. 18 Upper region, spectral comparison of exudate samples KT 2 and KT 20.

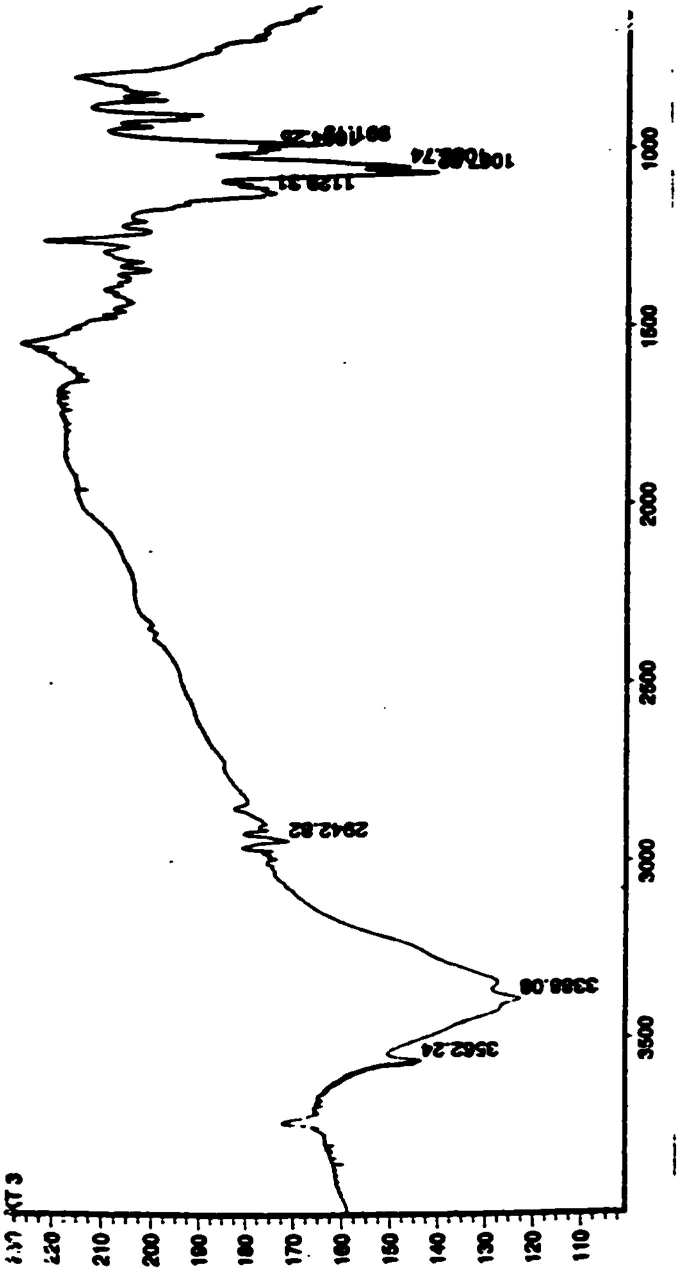


Fig. 19 Spectrum of exudate sample KT 3.

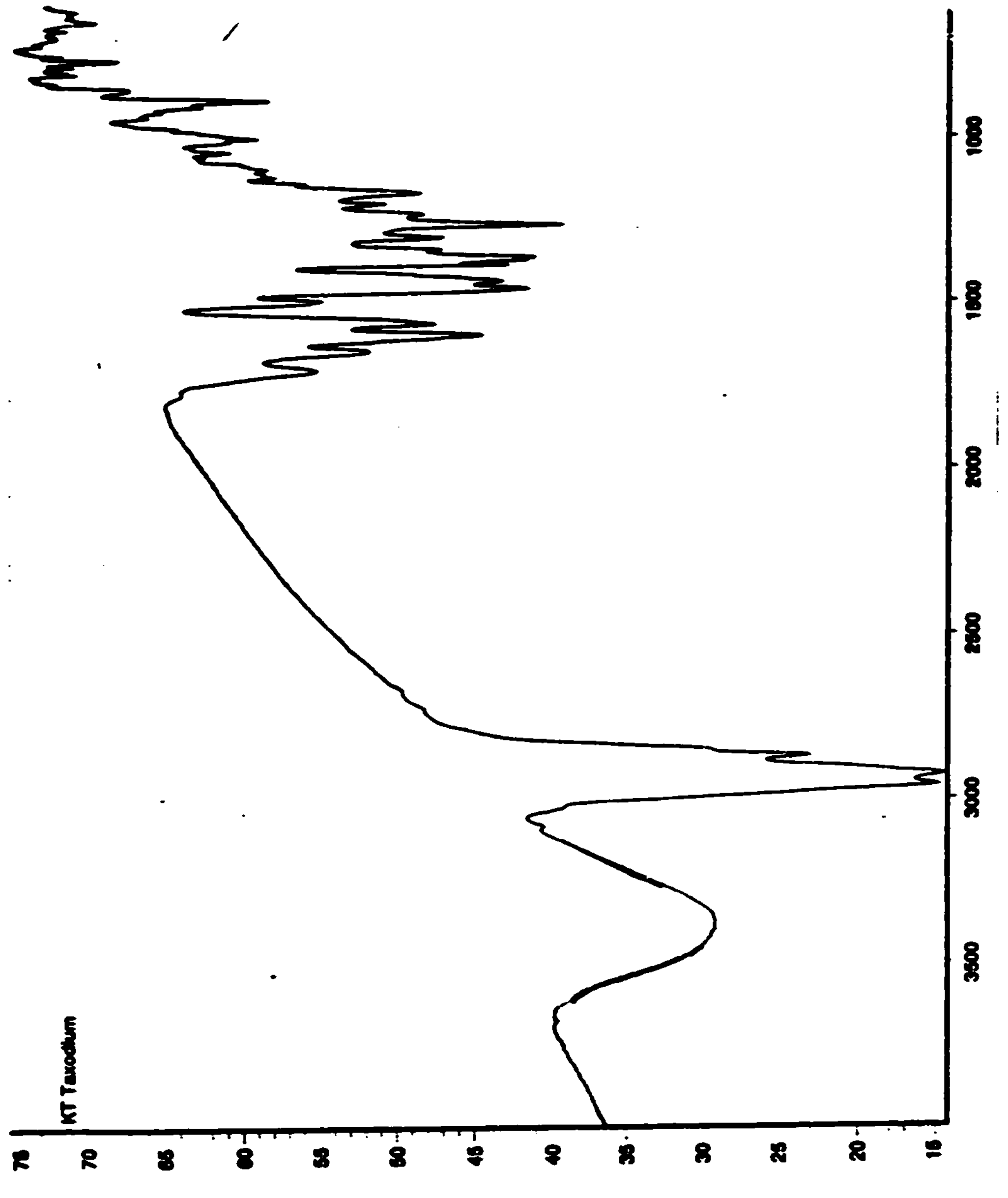


Fig. 20 Spectrum of exudate sample KT 25, *Taxodium* species, Taxodiaceae.

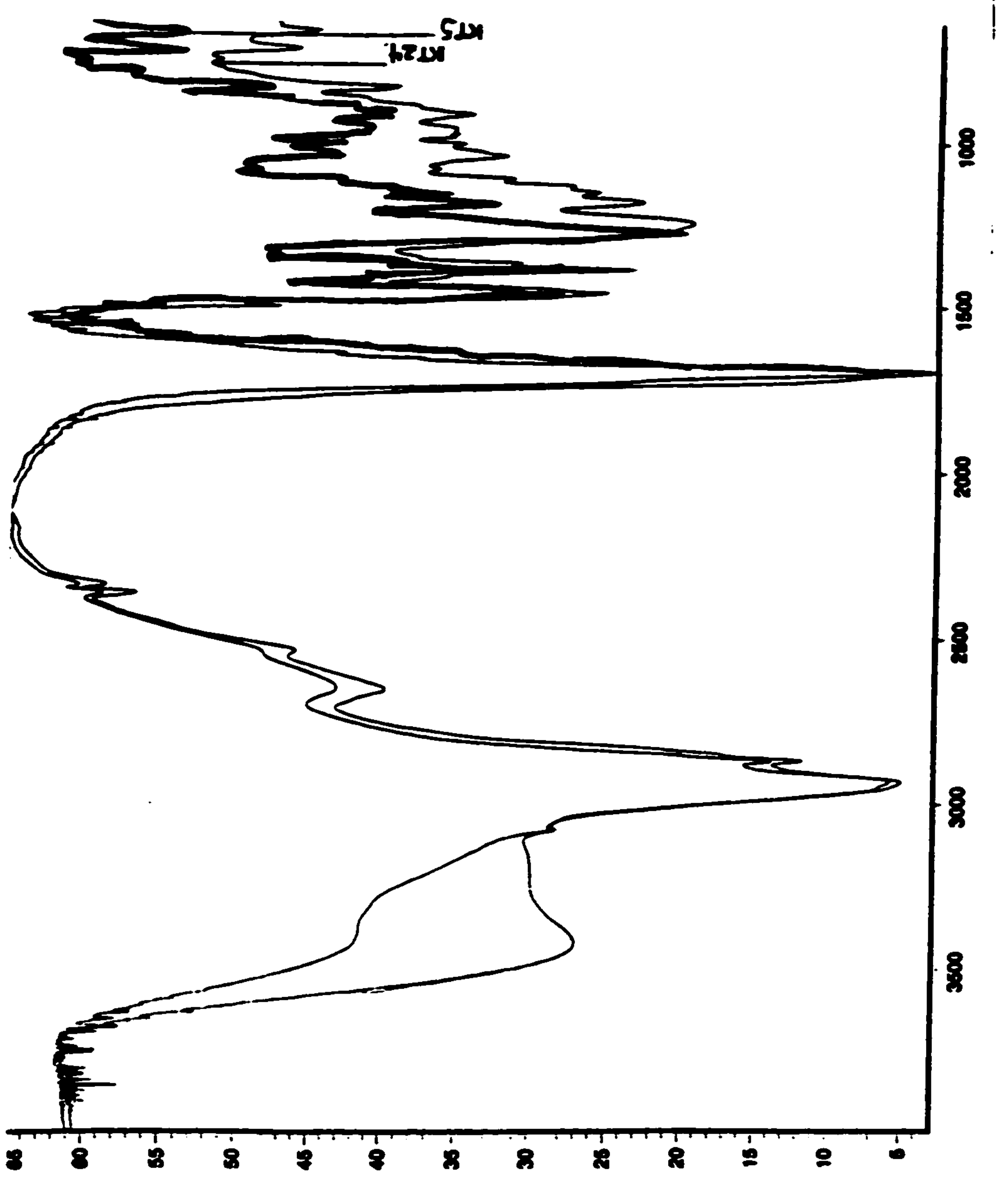


Fig. 21 Spectral comparison of exudate sample KT 5 and KT 24. Bold line in upper region is KT2 4.

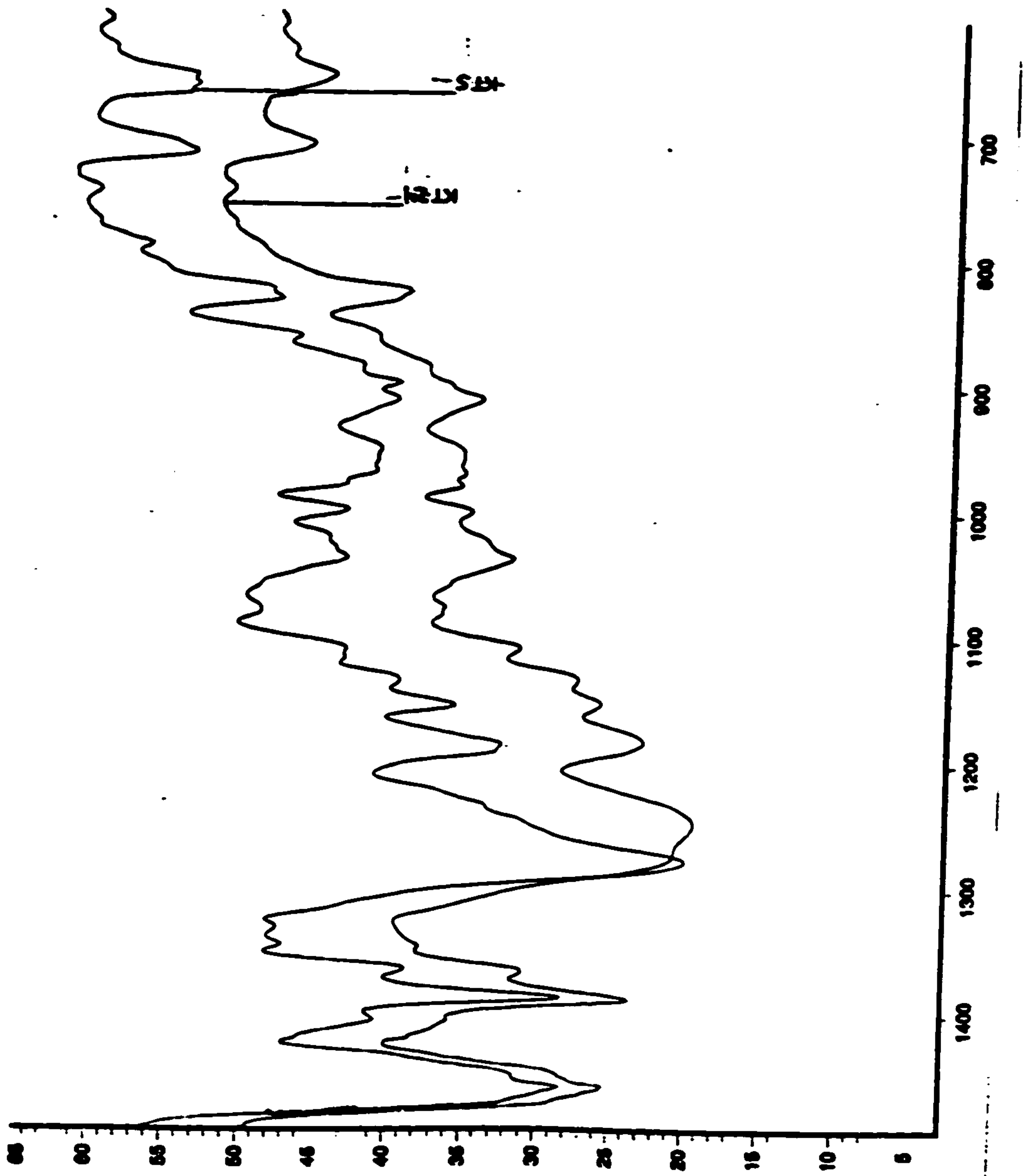


Fig. 22 Upper region, spectral comparison of exudate sample KT 5 and KT 24. Bold line in upper region is KT2 4.

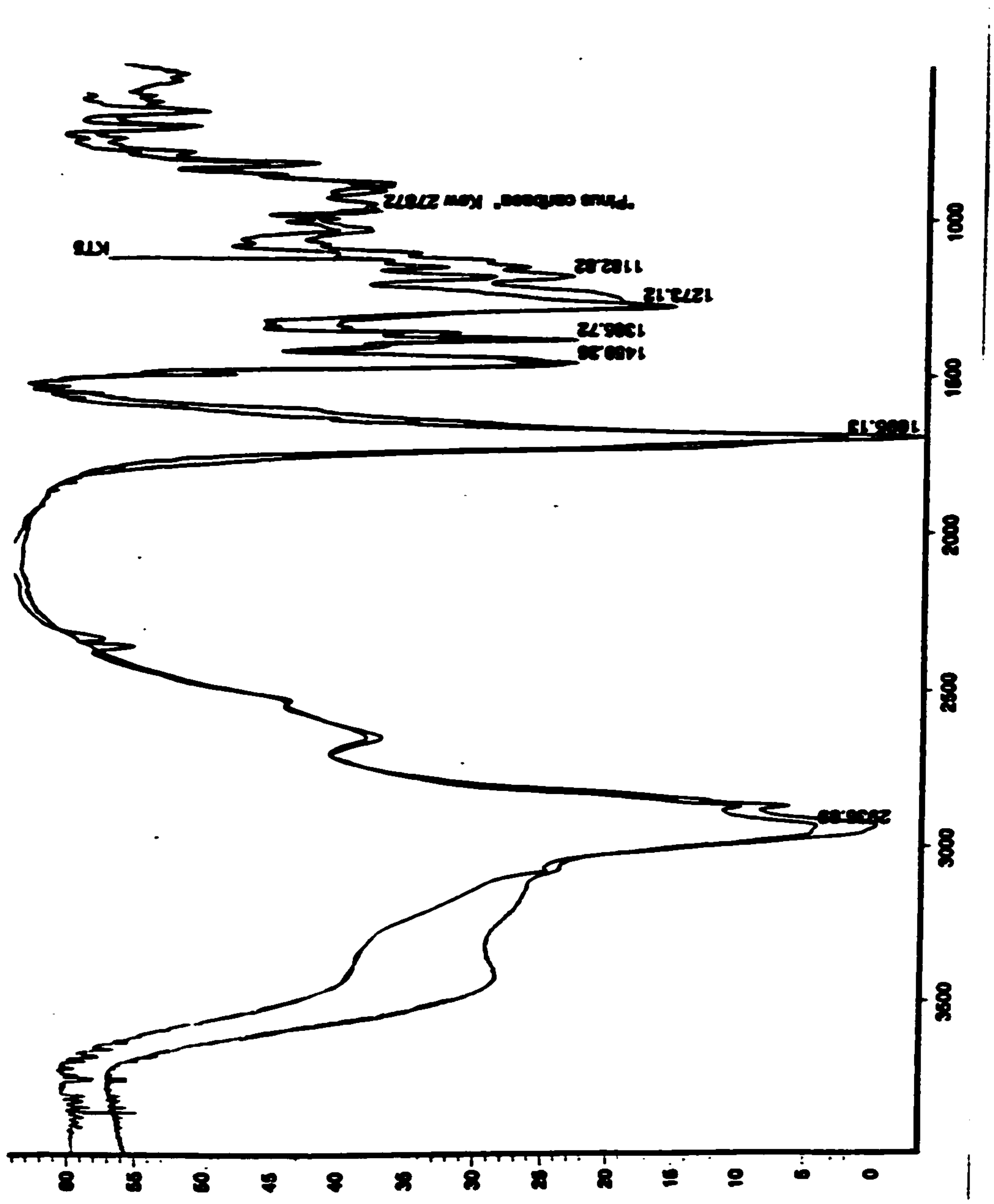


Fig. 23 Spectral comparison of KT 5 and *Pinus caribaea*, Pinaceae (Kew 27872).

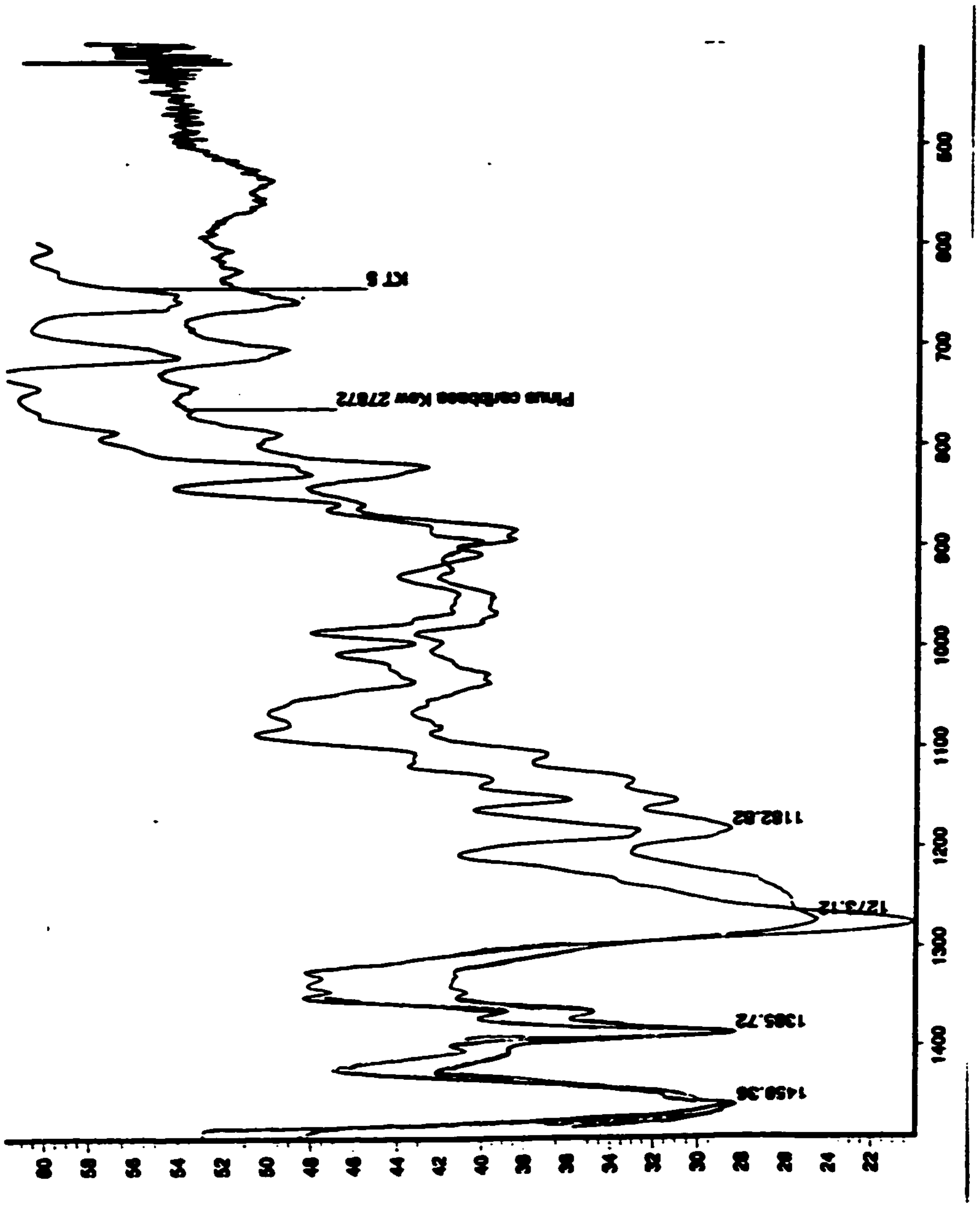


Fig. 24 Upper region, spectral comparison of KT 5 and *Pinus caribaea*, Pinaceae (Kew 27872).

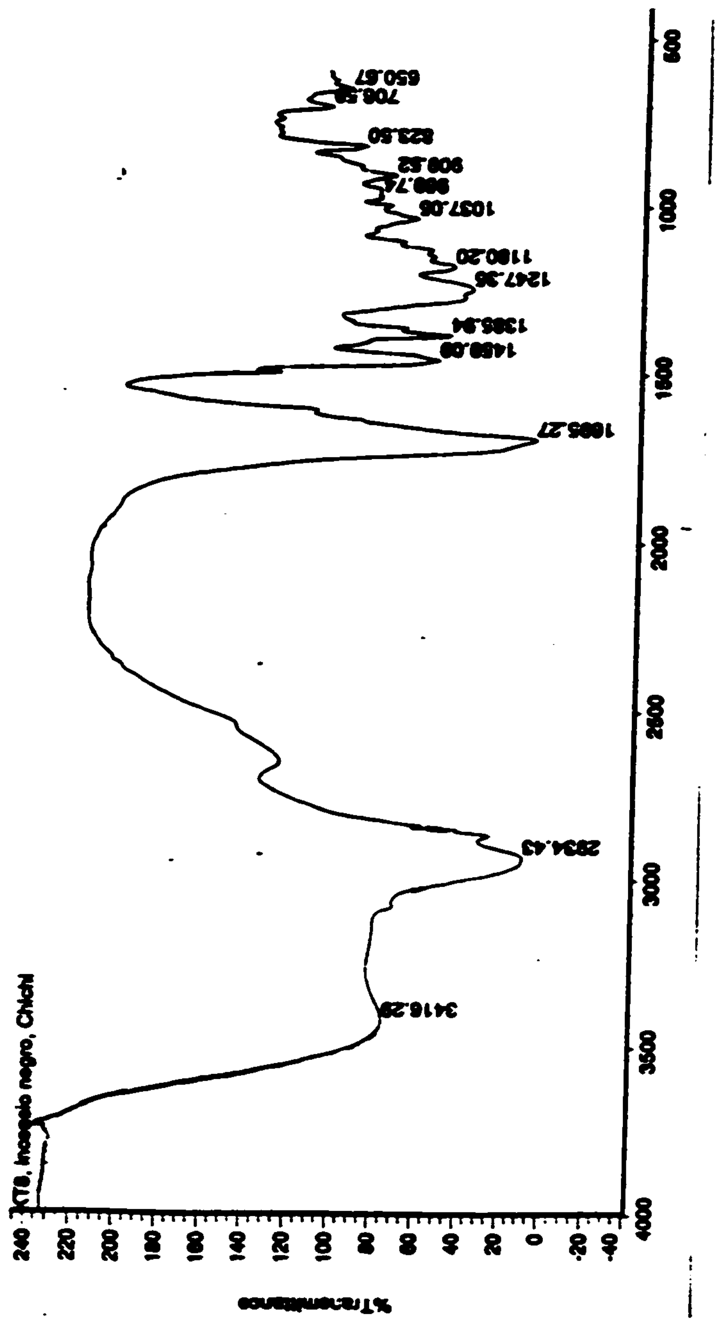


Fig. 25 Spectrum of exudate sample KT 8.

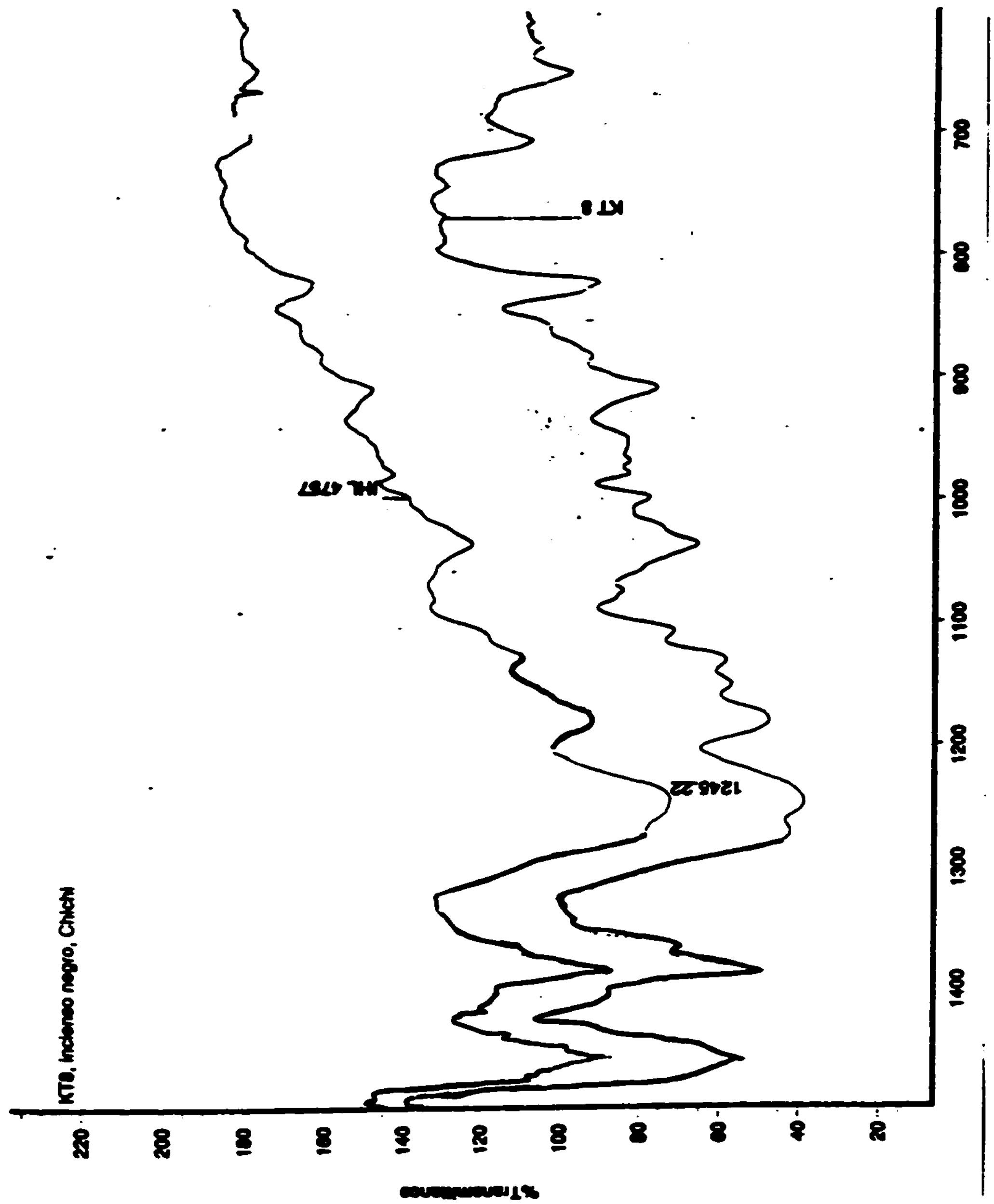


Fig. 26 Upper region, spectral comparison of exudate samples KT 8 and *Pinus oocarpa*, Pinaceae (JHL 4757).

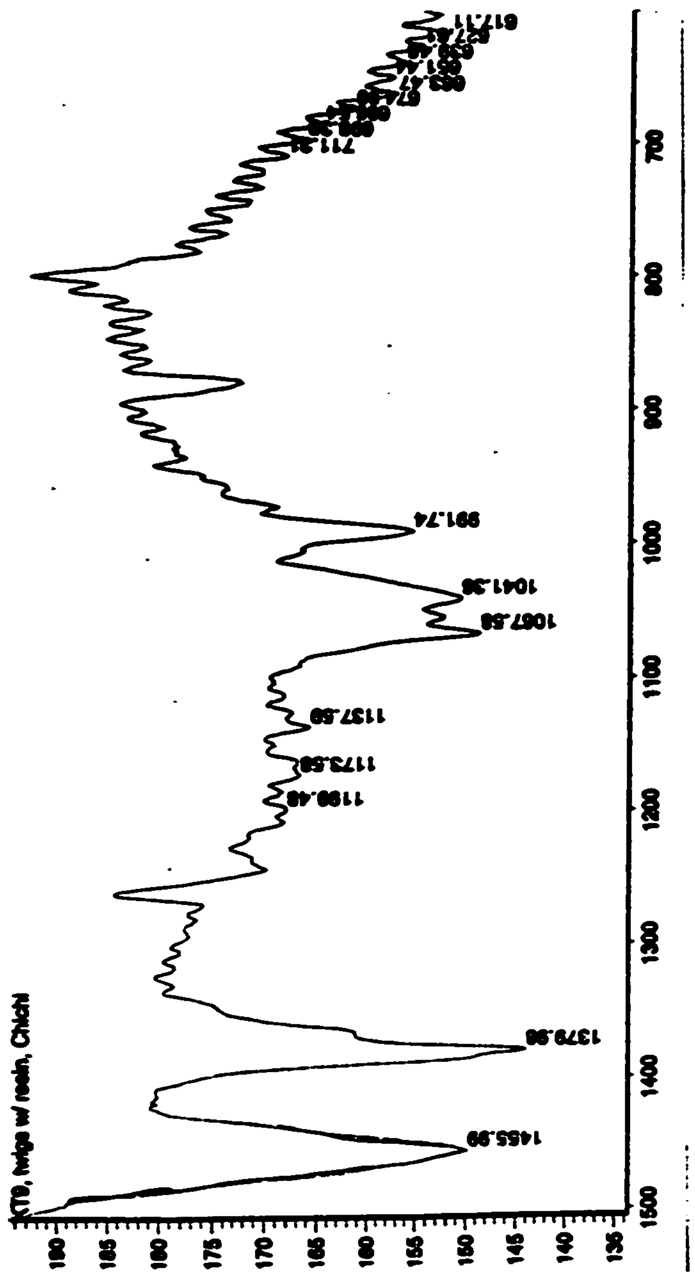


Fig. 27 Spectrum of exudate sample KT 8.

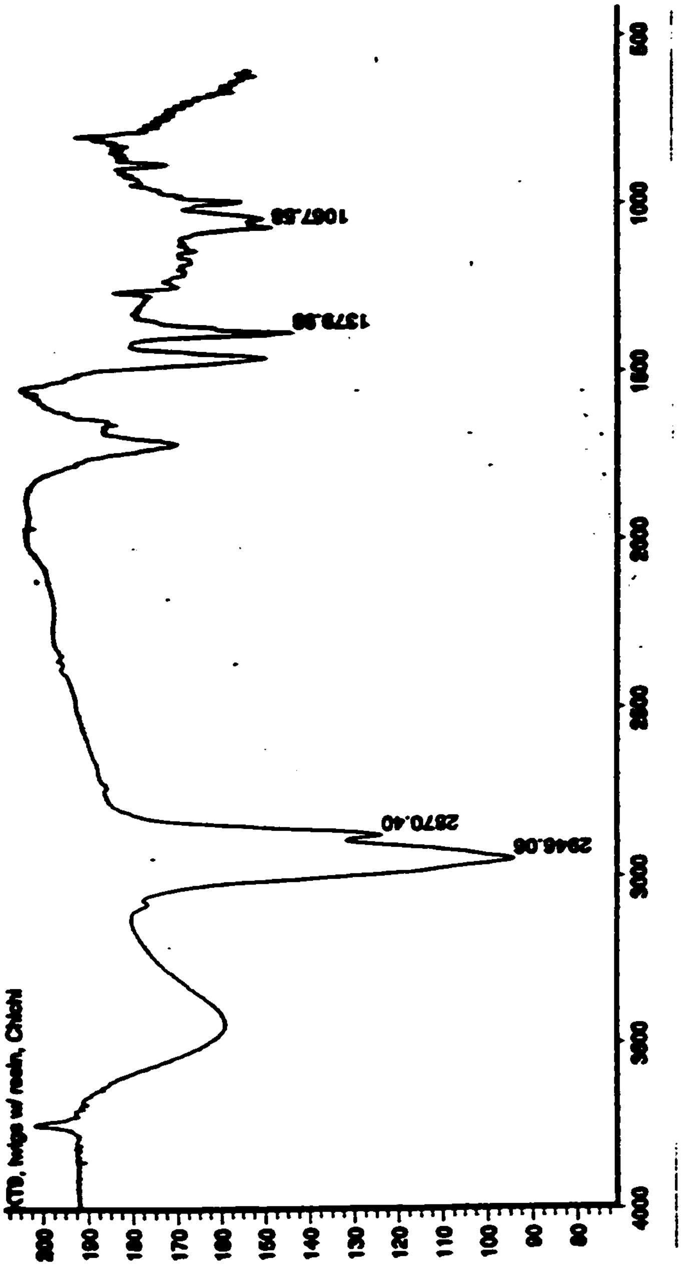


Fig. 28 Upper region, spectrum of exudate sample KT 9.

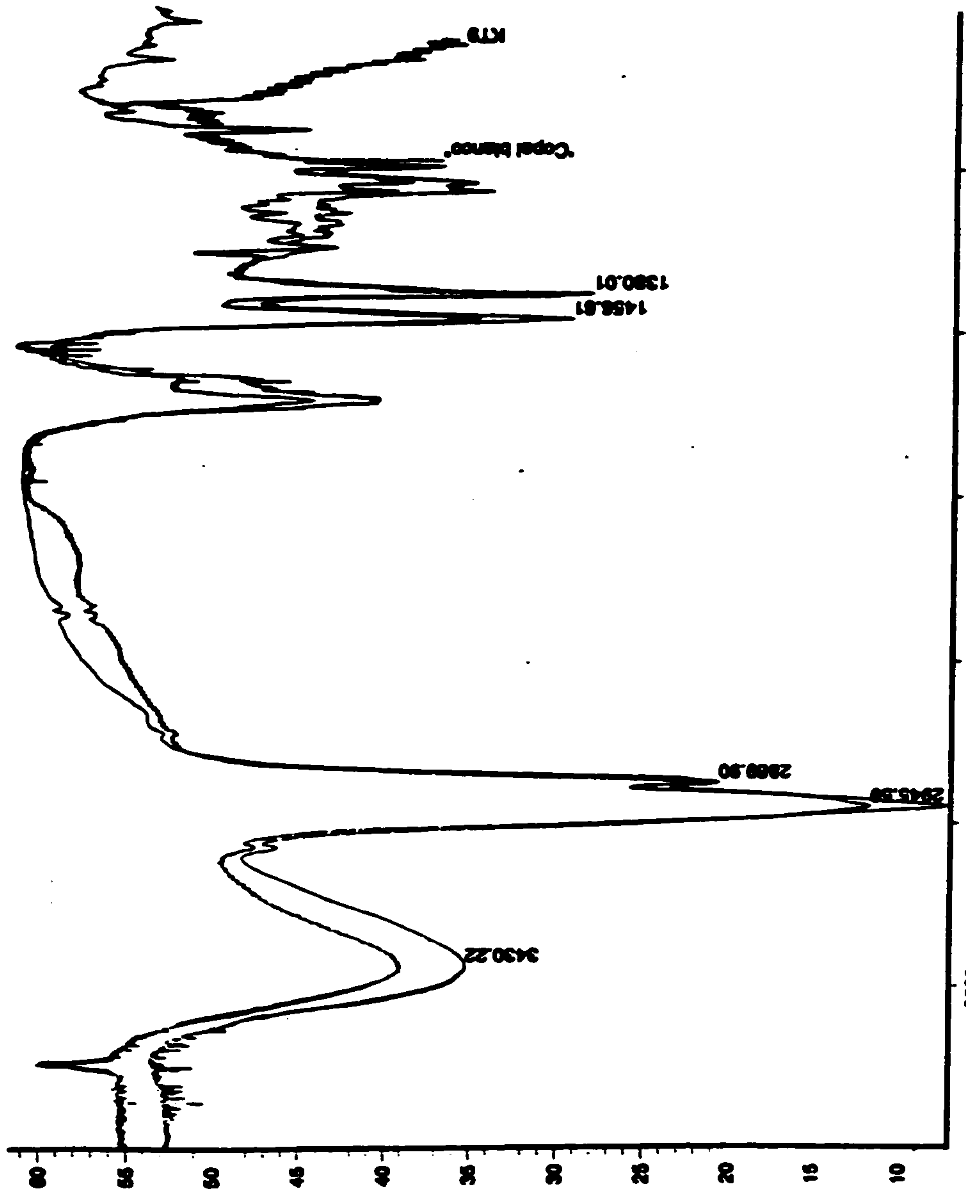


Fig. 29 Comparison of exudate samples KT 9 and Bye 2, Burseraceae.

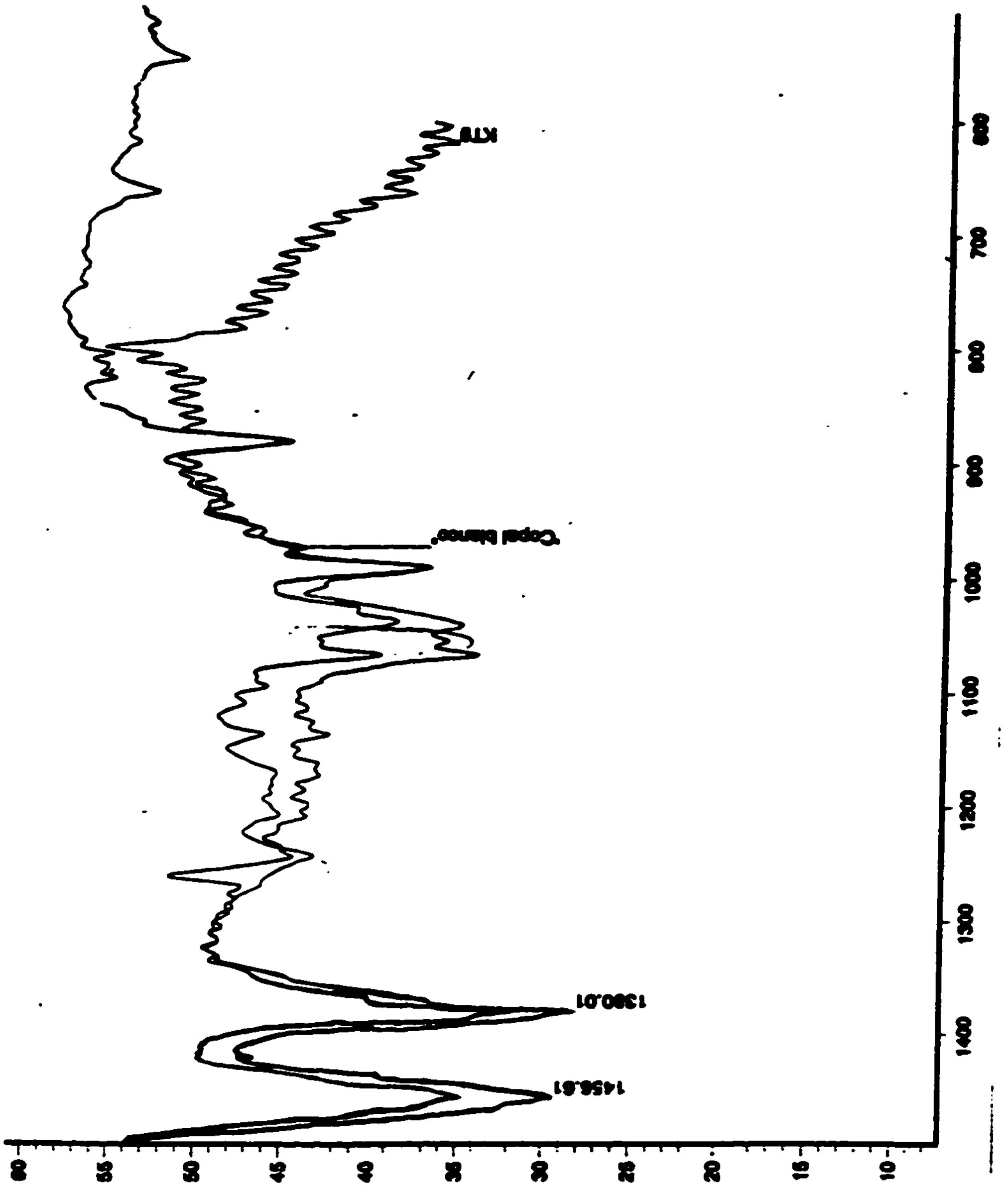


Fig. 30, Upper region, spectral comparison of exudate samples KT 9 and Bye 2, Burseraceae.

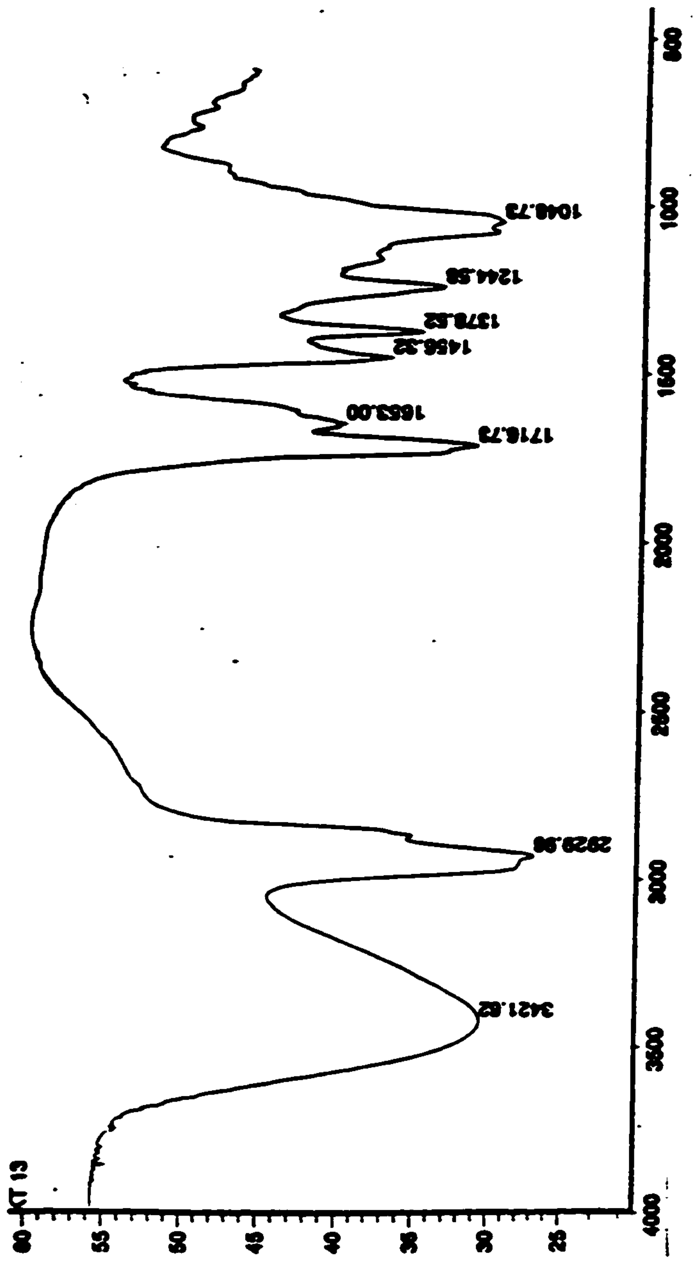


Fig. 31 Spectrum of exudate sample of KT 13.

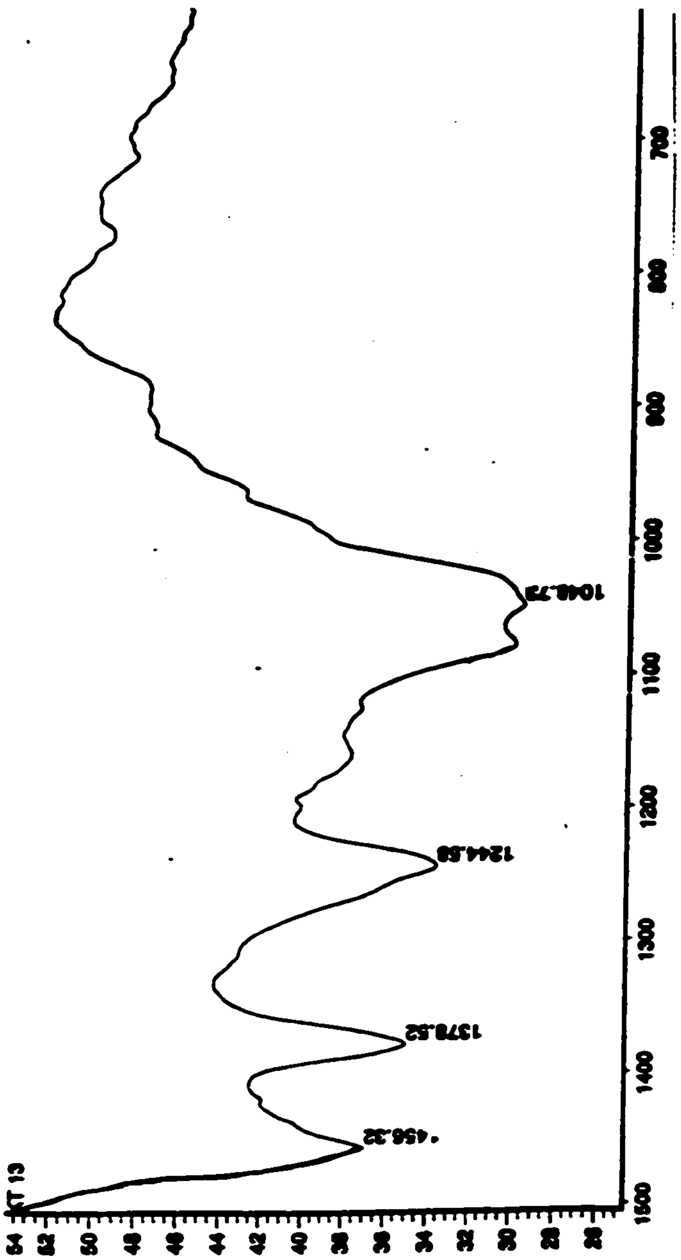


Fig. 32 Upper region, spectrum of exudate KT 13.

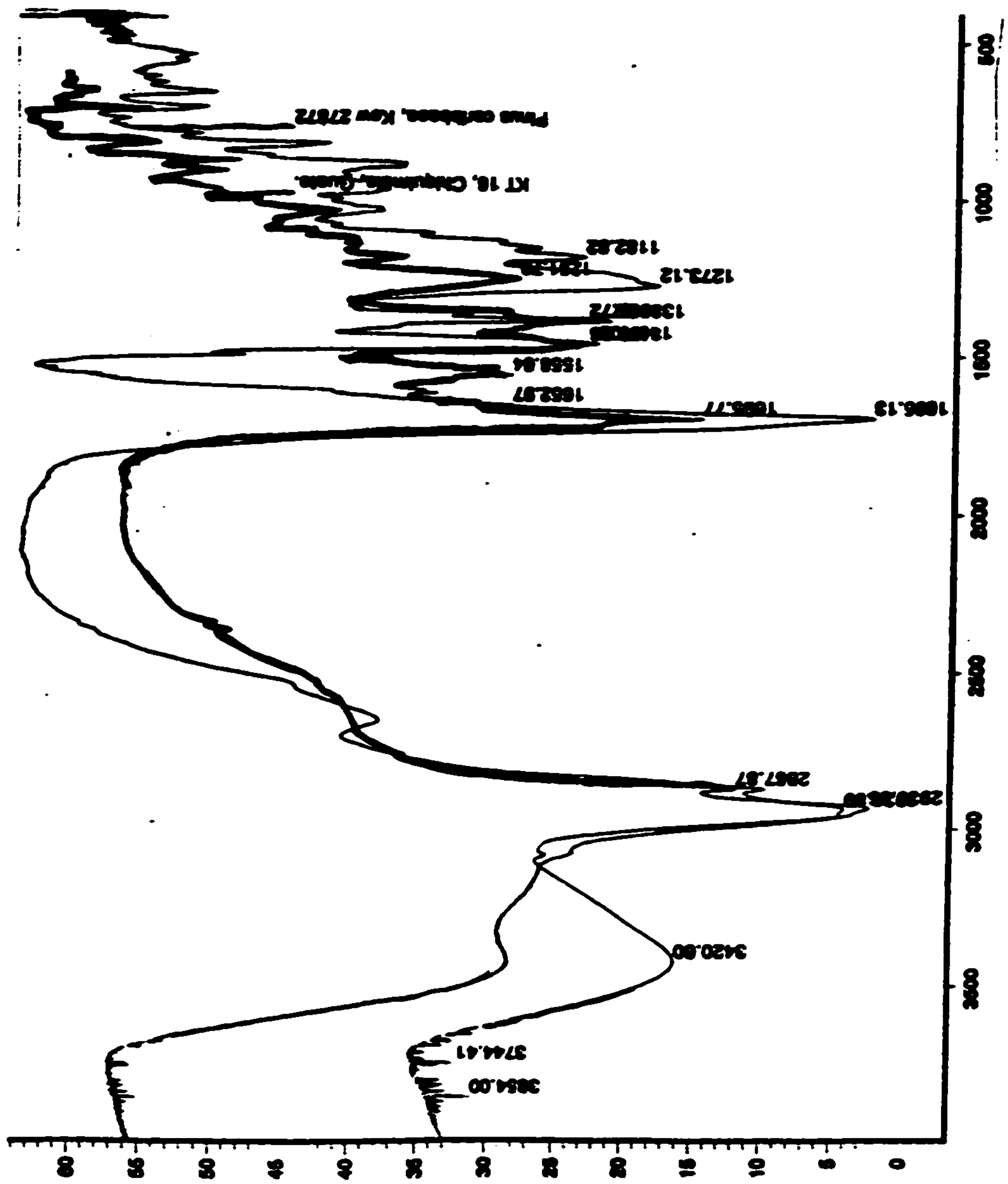


Fig. 33 Spectral comparison of exudate samples KT 16 and *Pinus caribaea* var. *hondurensis*, Pinaceae (Kew 27872).

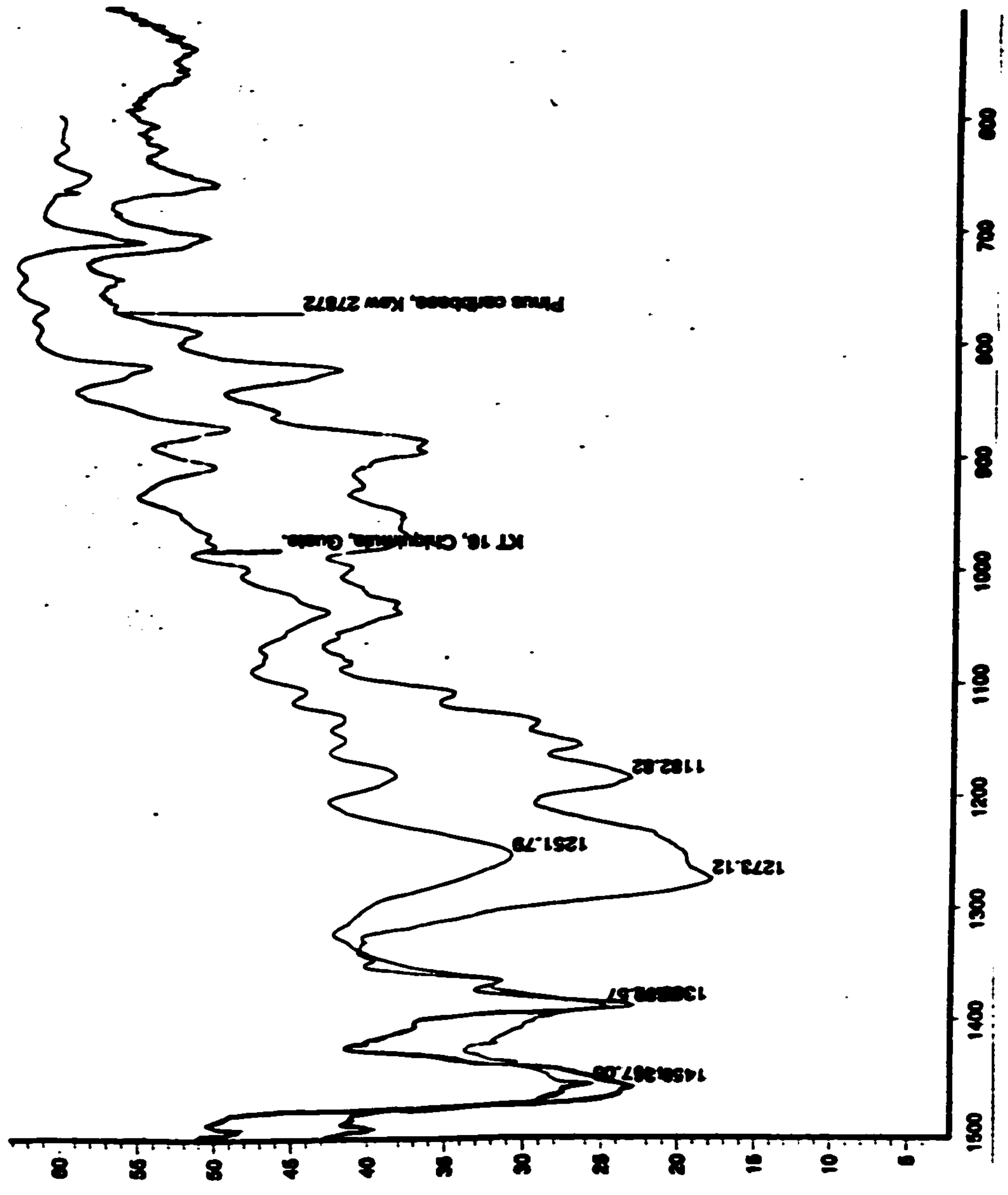


Fig. 34 Upper region, spectral comparison of exudate samples KT 16 and *Pinus caribaea* var. *hondurensis*, Pinaceae (Kew 27872).

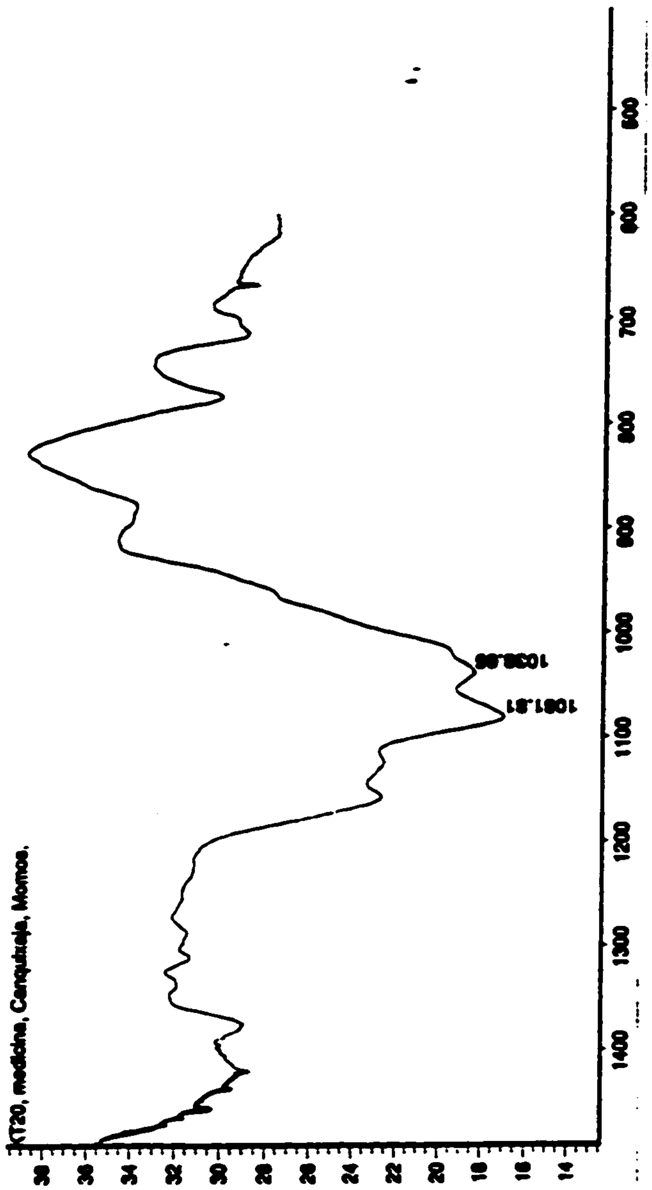


Fig. 35 Spectrum of exudate sample KT 20.

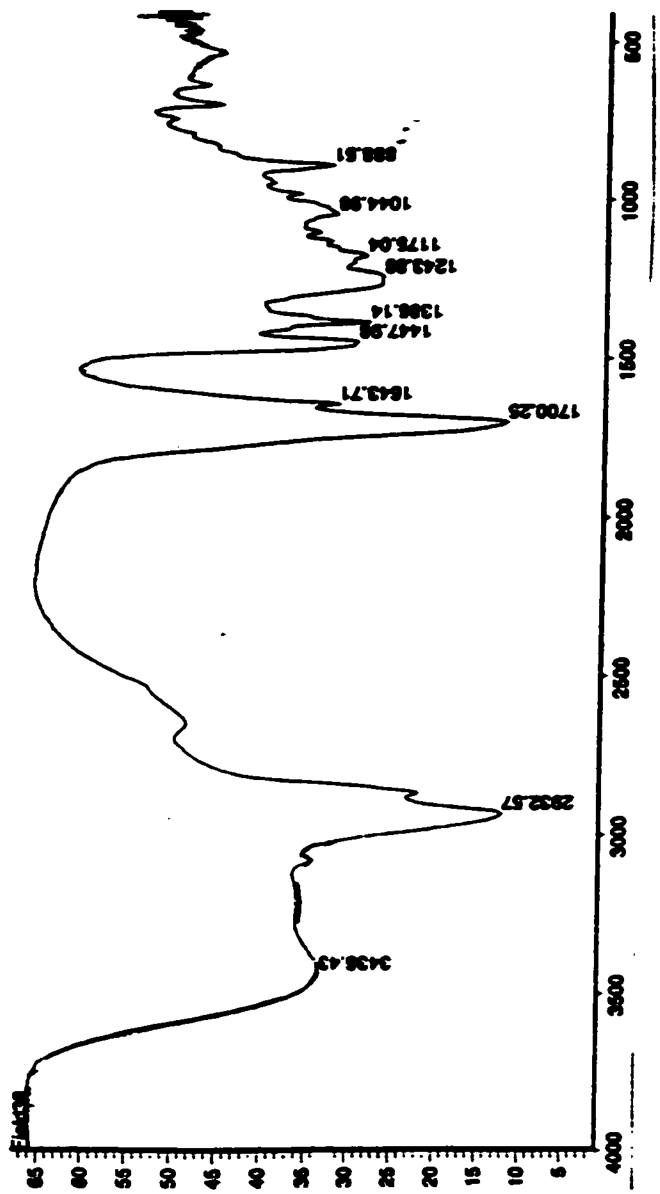


Fig. 36 Spectrum of exudate sample *Bursera graveolens*, Burseraceae (F 38).

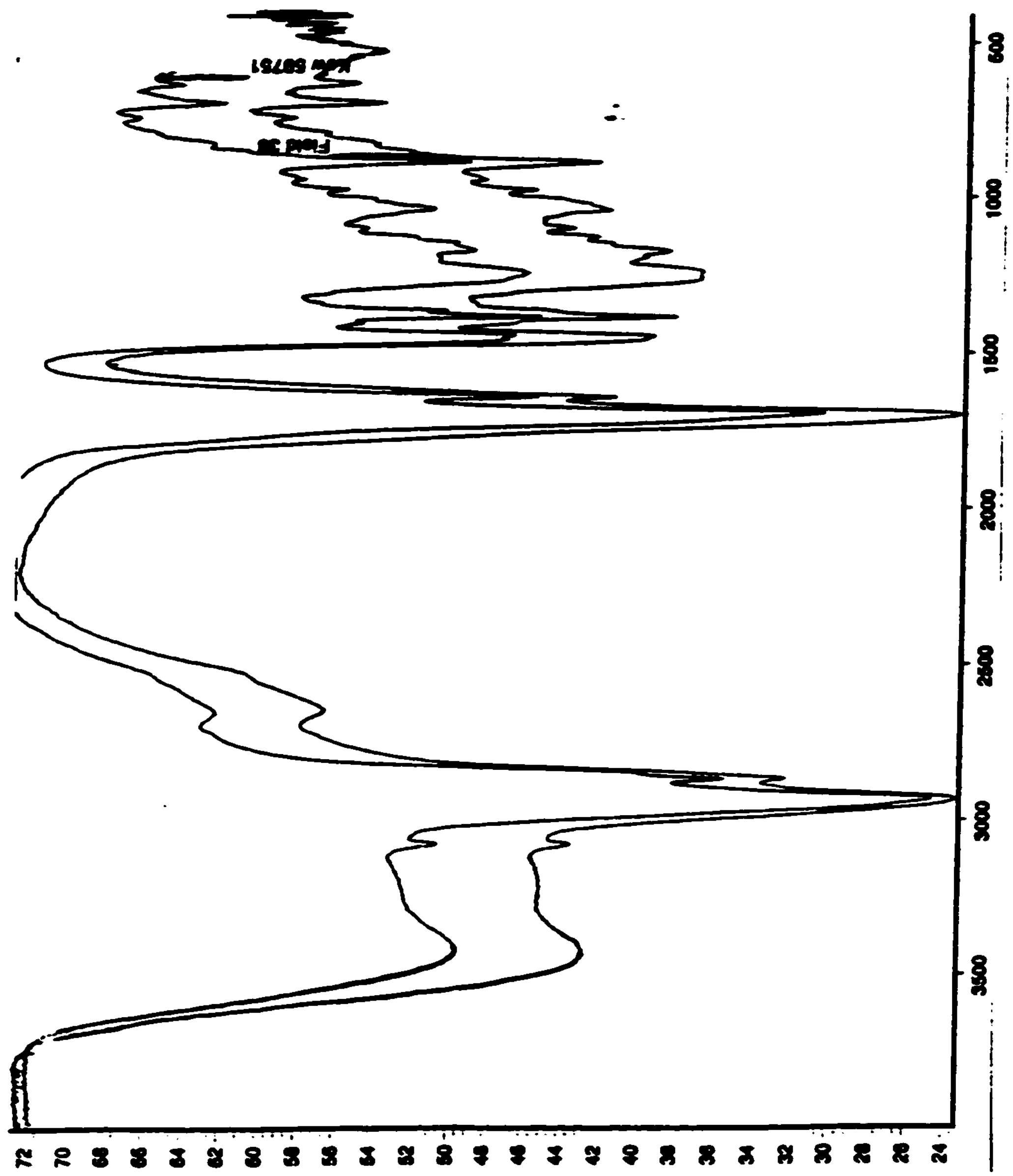


Fig. 37 Spectral comparison of *Bursera graveolens*, Burseracae (F 38) and *Hymenaea courbaril* (Fabaceae Kew 59751).

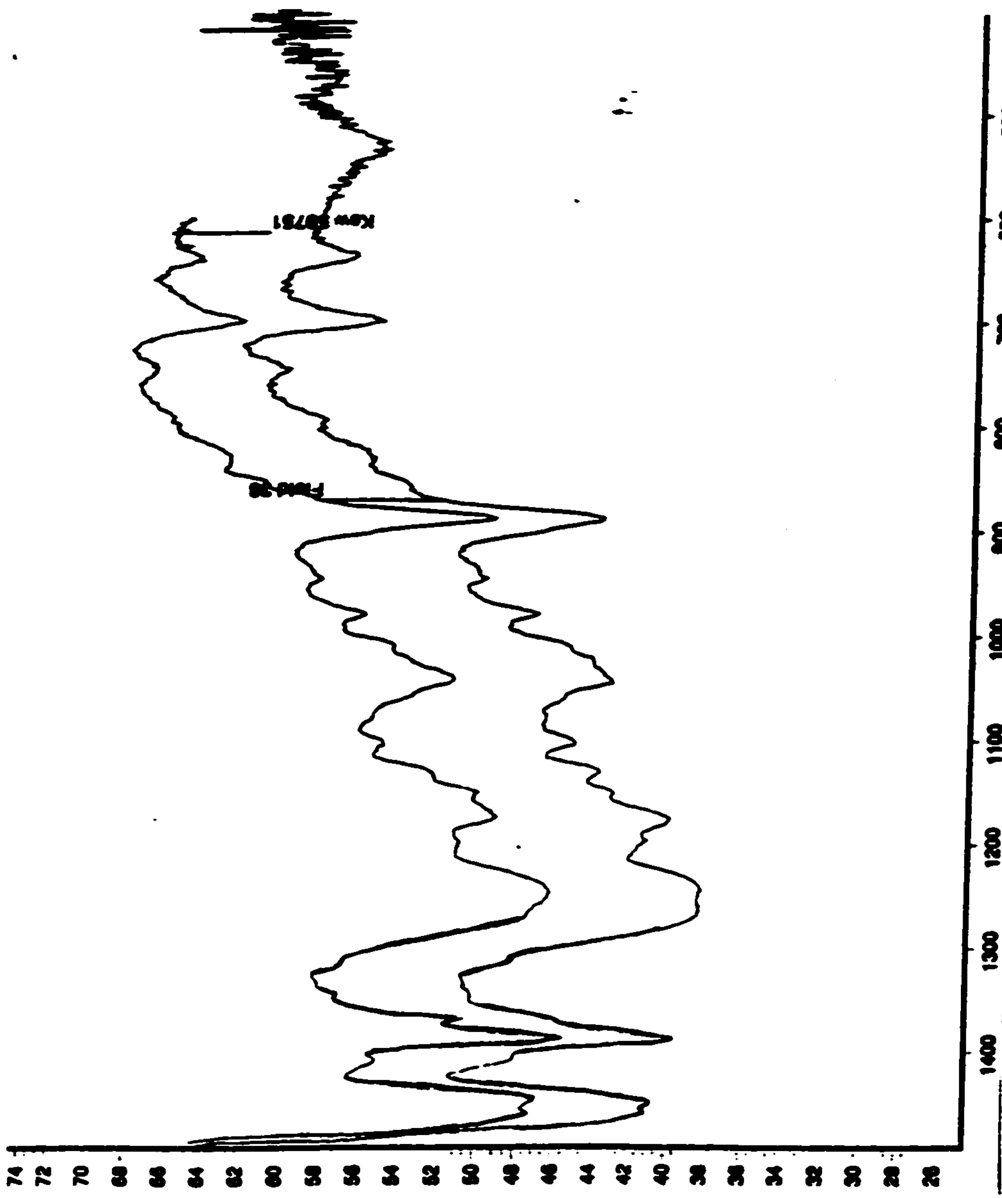


Fig. 38 Upper region, spectral comparison of *Bursera graveolens*, Burseracae (F 38) and *Hymenaea courbaril* (Fabaceae Kew 59751).

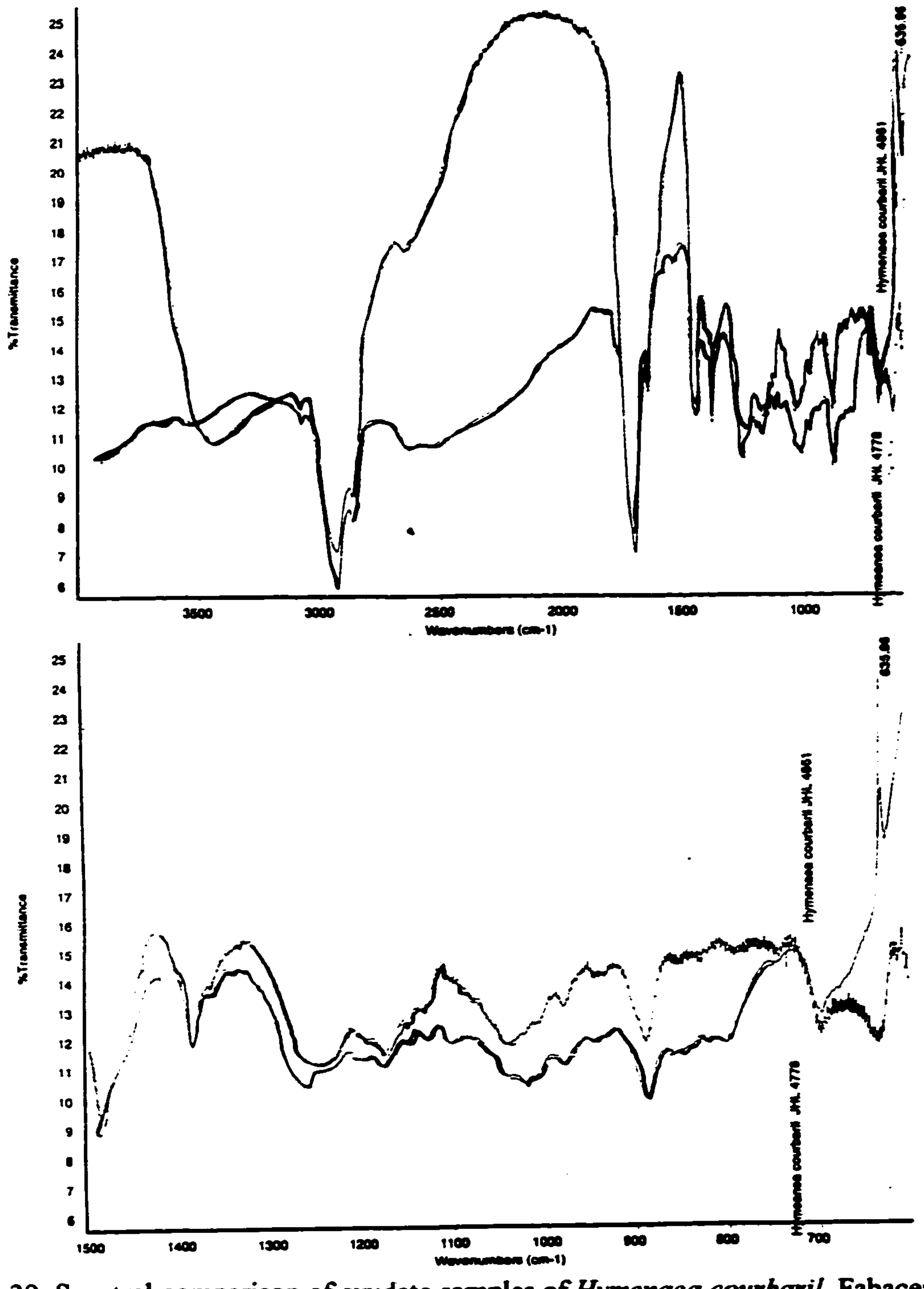


Fig. 39 Spectral comparison of exudate samples of *Hymenaea courbaril*, Fabaceae (JHL 4861 and JHL 4778).

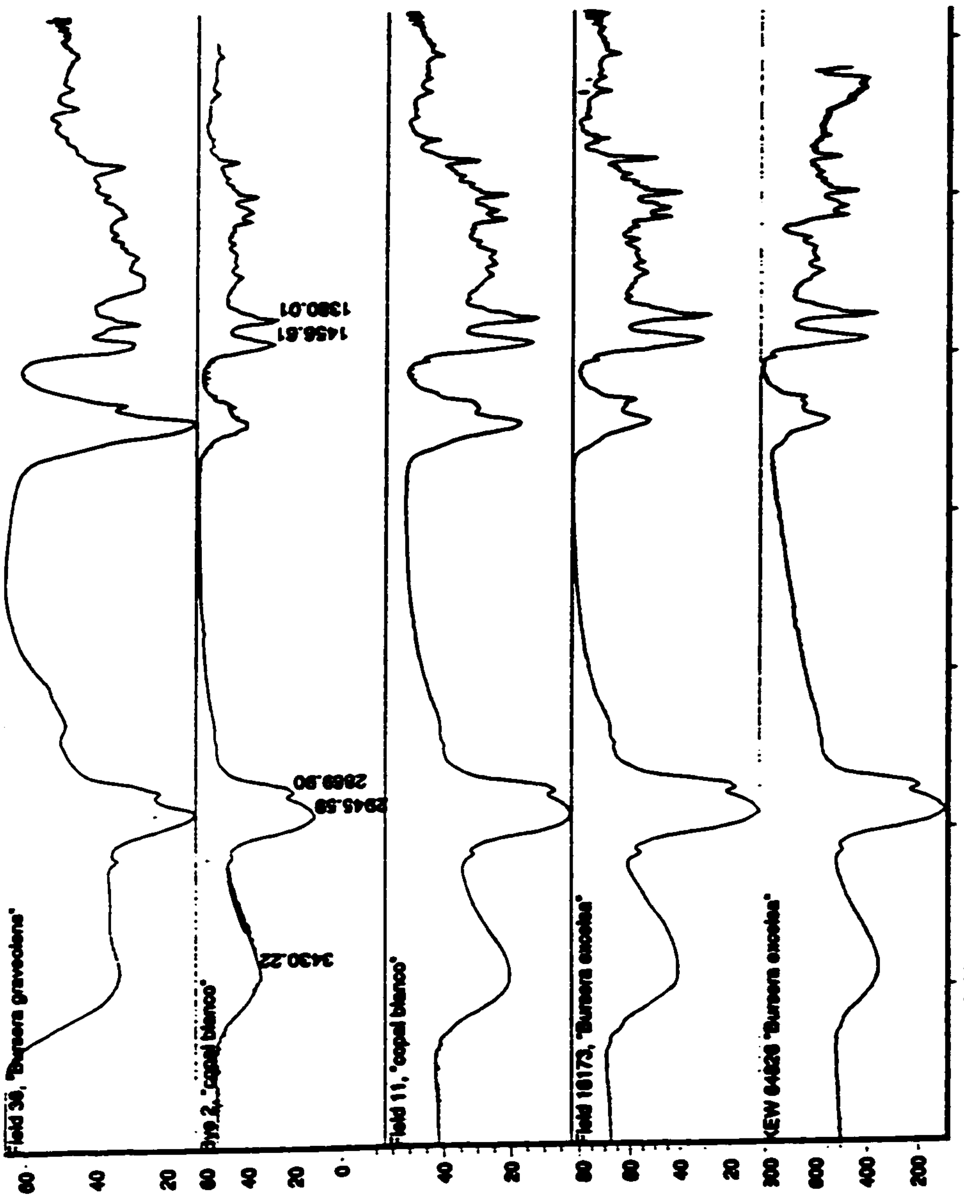


Fig. 40 Spectral comparison of ***Bursera graveolens*** (Field 38), Bye 2, Field 11, ***Bursera excelsa*** (Field 16173), ***Bursera excelsa*** (Kew 64826).

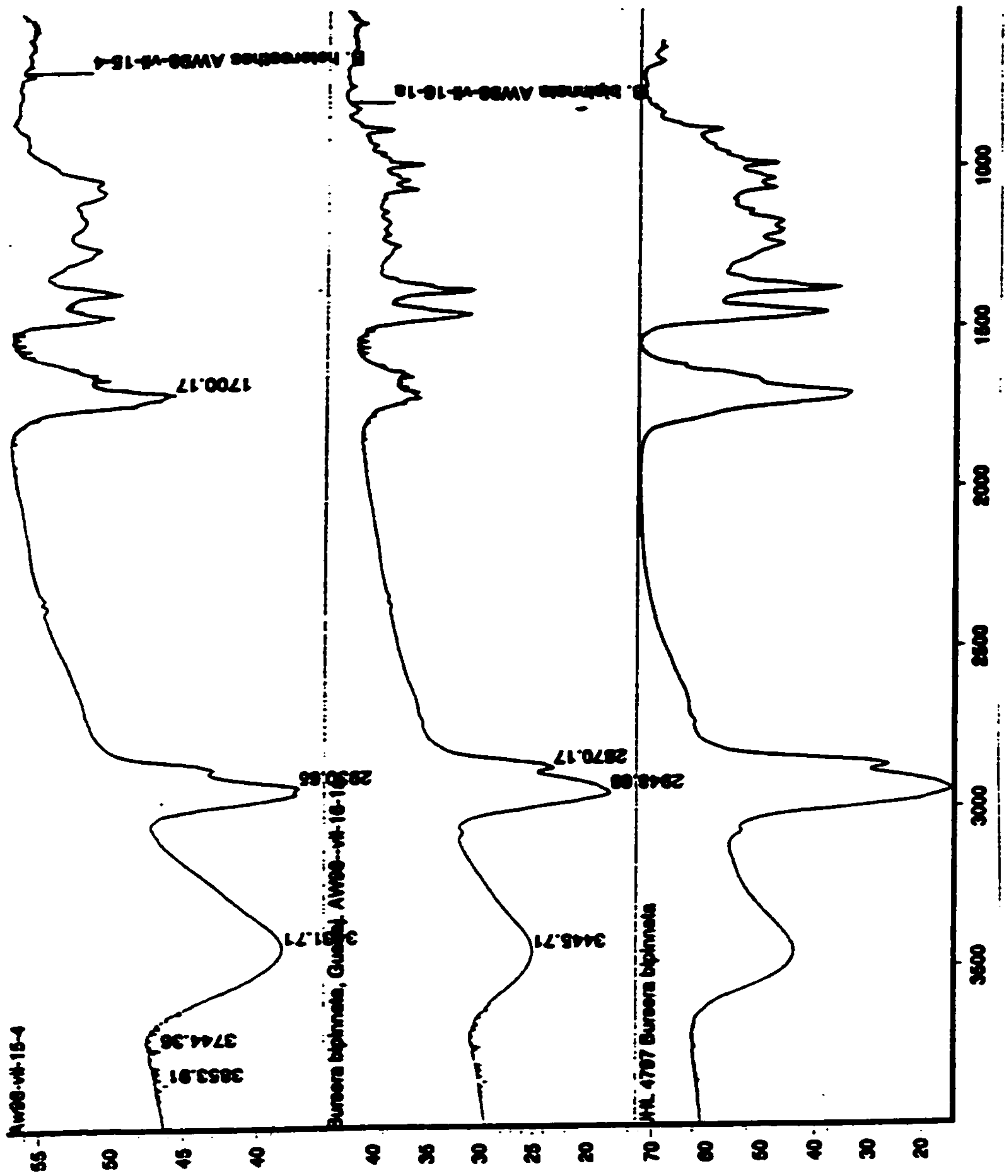


Fig. 41 Spectral comparison of exudate samples *Bursera bipinnata* (AW98-VII-15-4), *Bursera heteresthes* (AW98-VII-16-1(a), and *Bursera heteresthes* (JHL 4797).

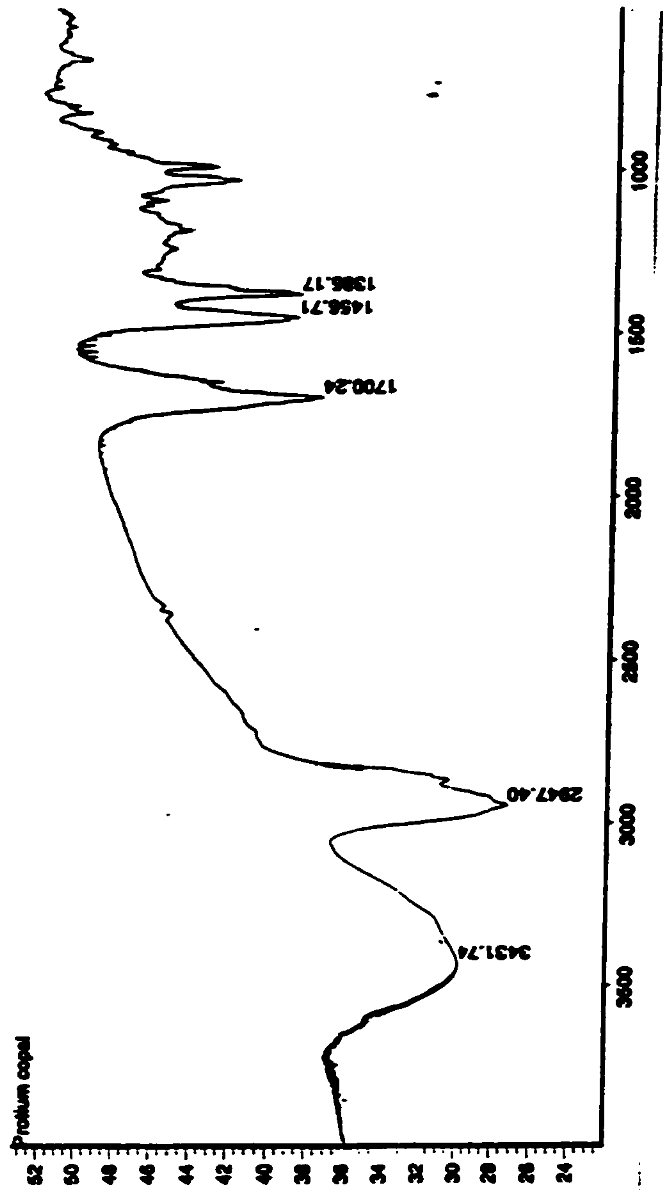


Fig. 42 Spectrum for *Protium copal* (Burseraceae, KT 23).

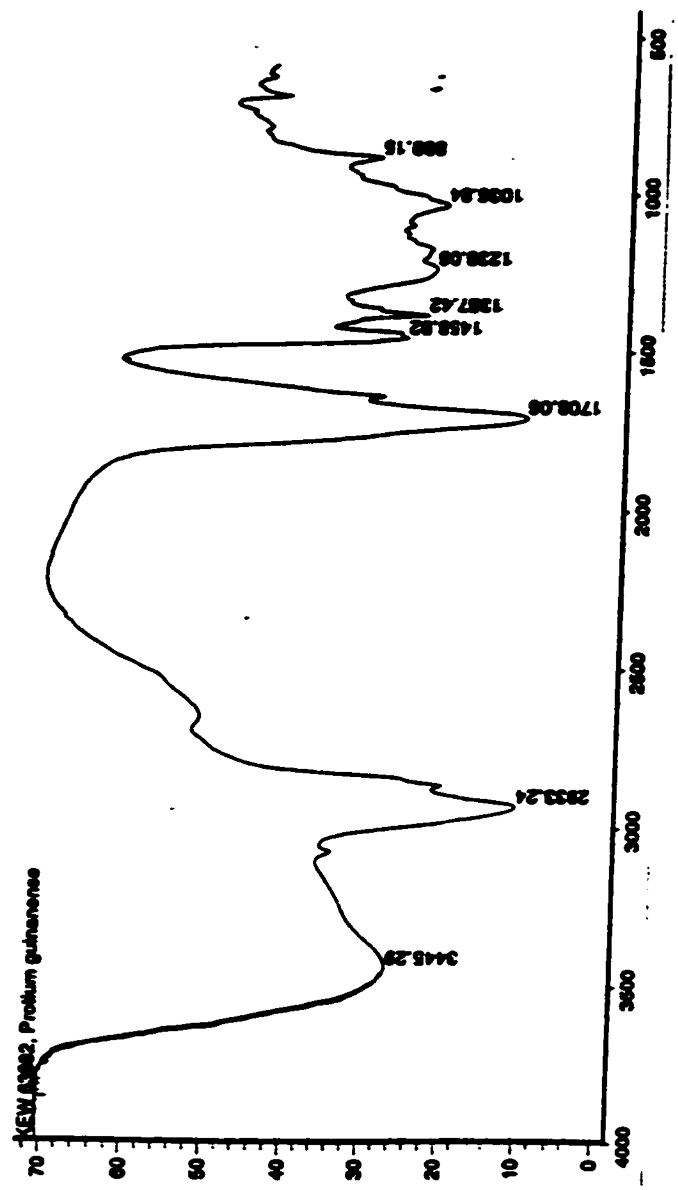


Fig. 43 Spectrum of *Protium guianense*, Burseraceae (Kew 63882), a South American taxa.

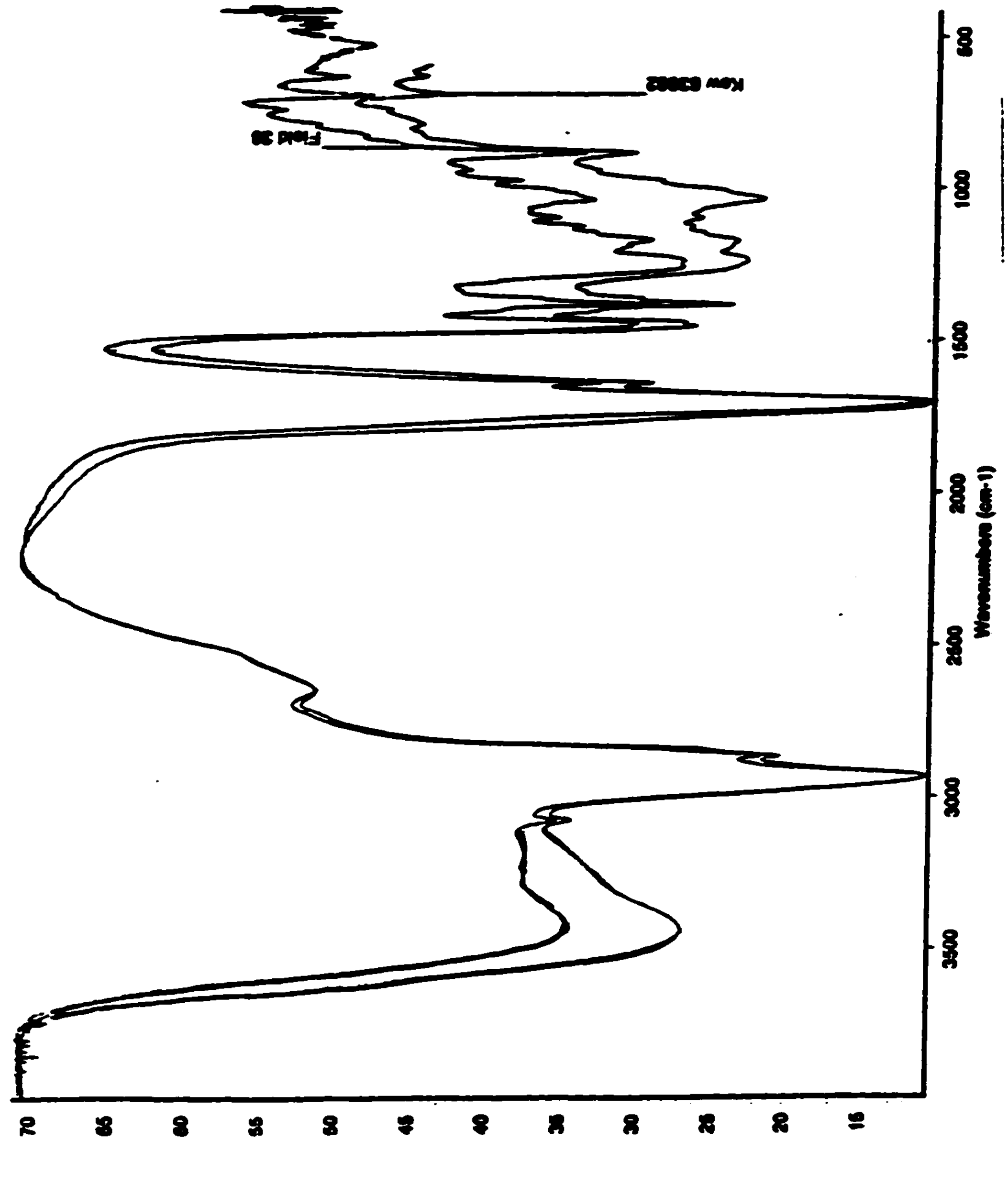


Fig. 44 Spectral comparison of exudate samples *Protium guianense* (Kew 63882) and *Bursera graveolens* (Field 38).

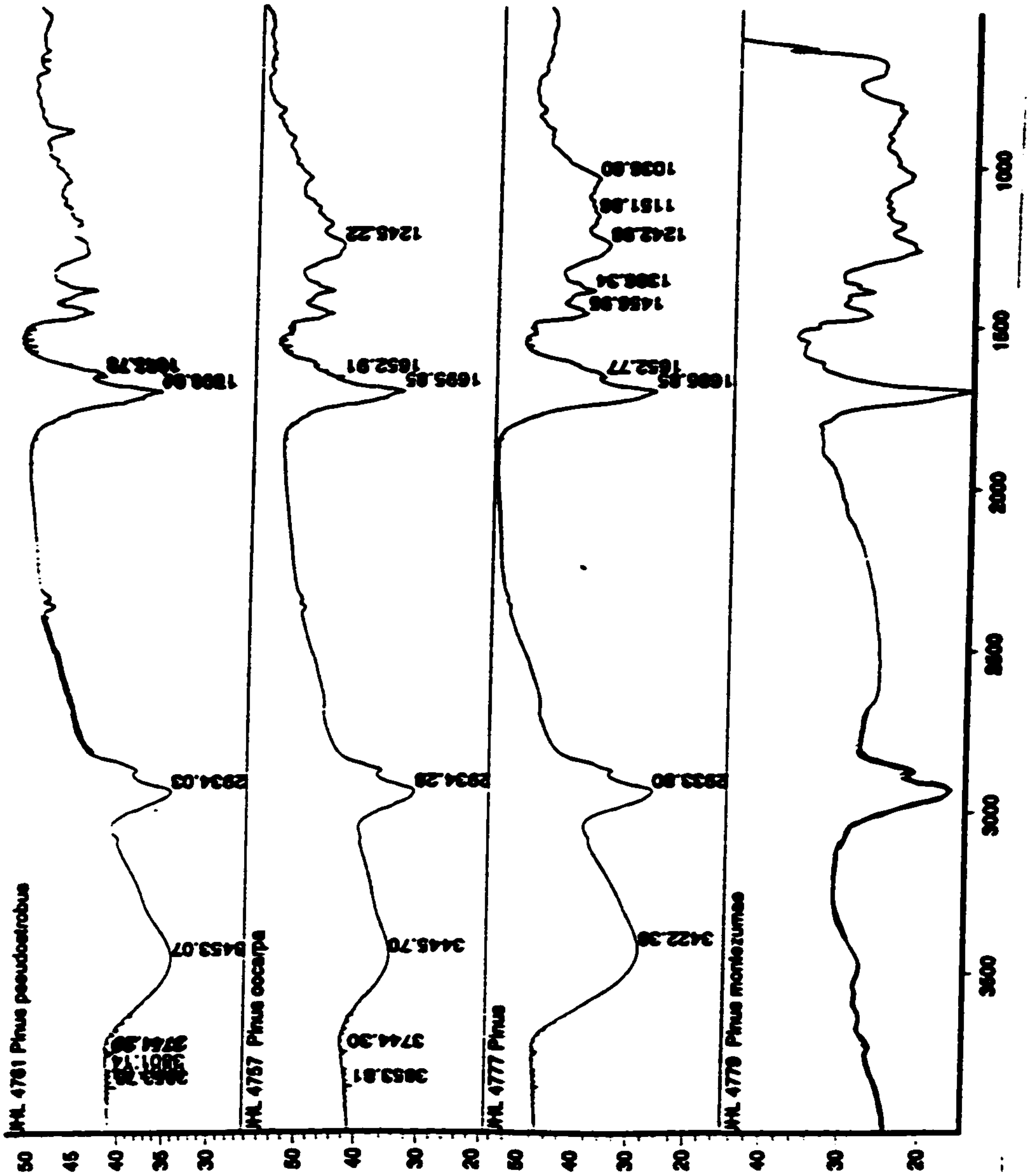


Fig. 45 Spectral comparison exudate samples *Pinus psuedostrobus*, Pinaceae (JHL 4761), *P. oocarpa* (JHL 4757), *P. strobus* var. *chiapensis* (JHL 4777, and *P. montezumae* (JHL 4779).

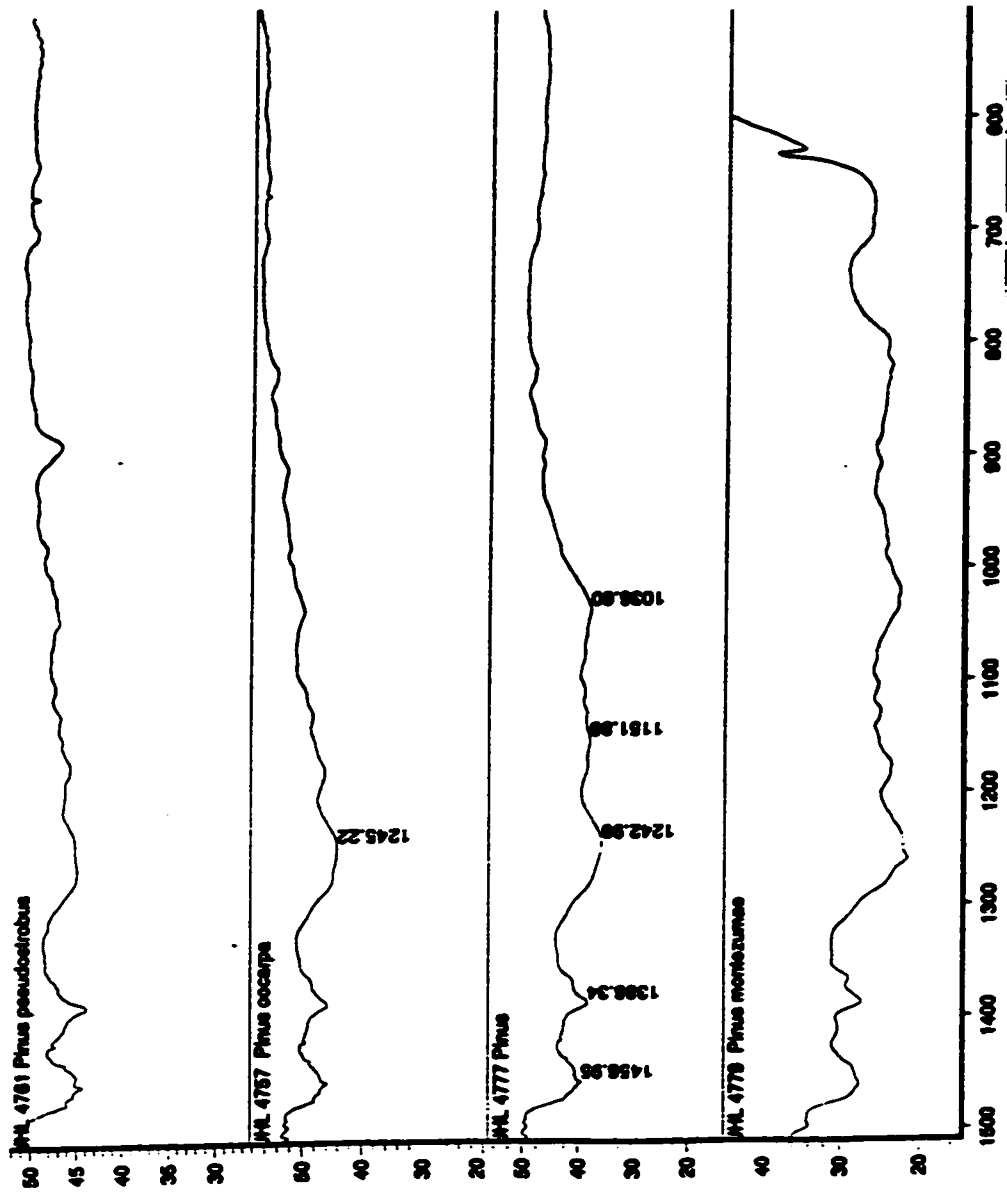


Fig. 46 Upper region, spectral comparison exudate samples *Pinus psuedostrobus*, Pinaceae (JHL 4761), *P. oocarpa* (JHL 4757), *P. strobus* var. *chiapensis* (JHL 4777, and *P. montezumae* (JHL 4779).

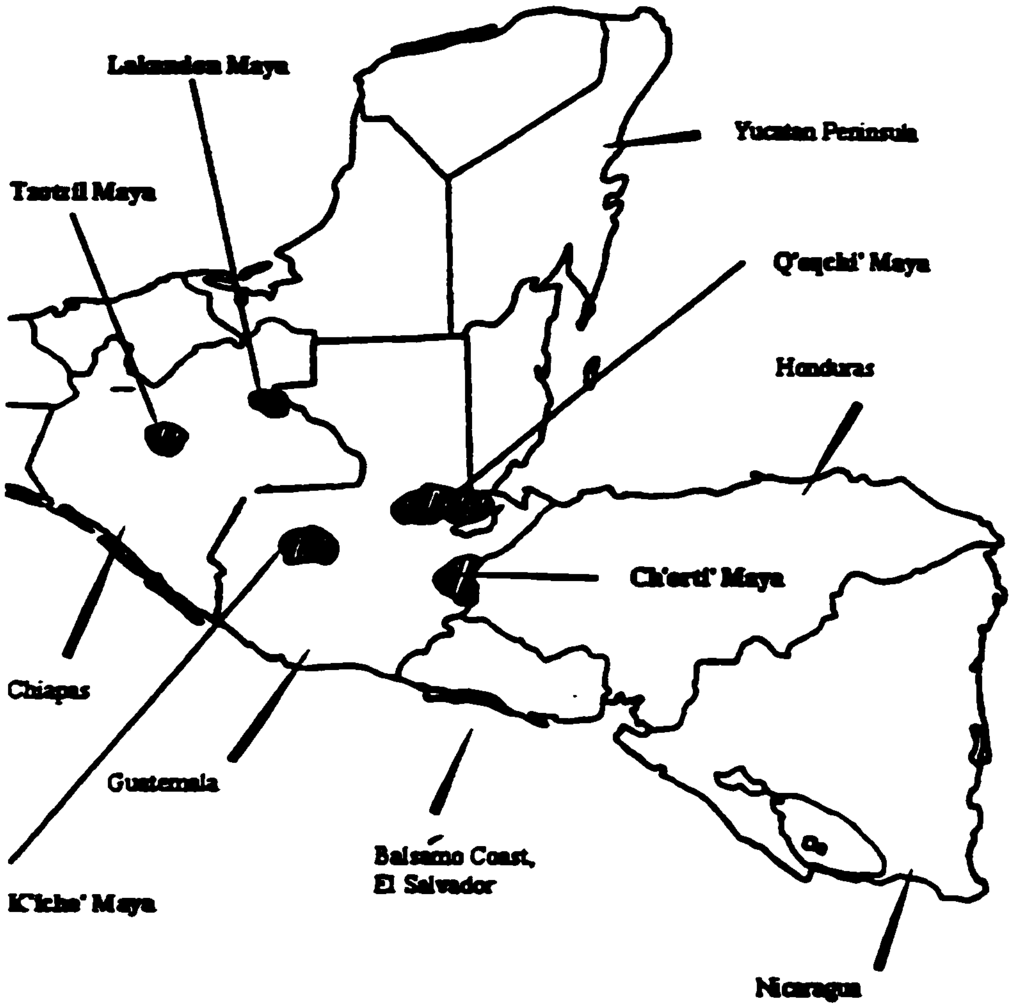


Fig. 47 General map of southern Mexico and Central America: the Maya cultural region under study., including approximate locations of Maya ethnic groups considered in this study.

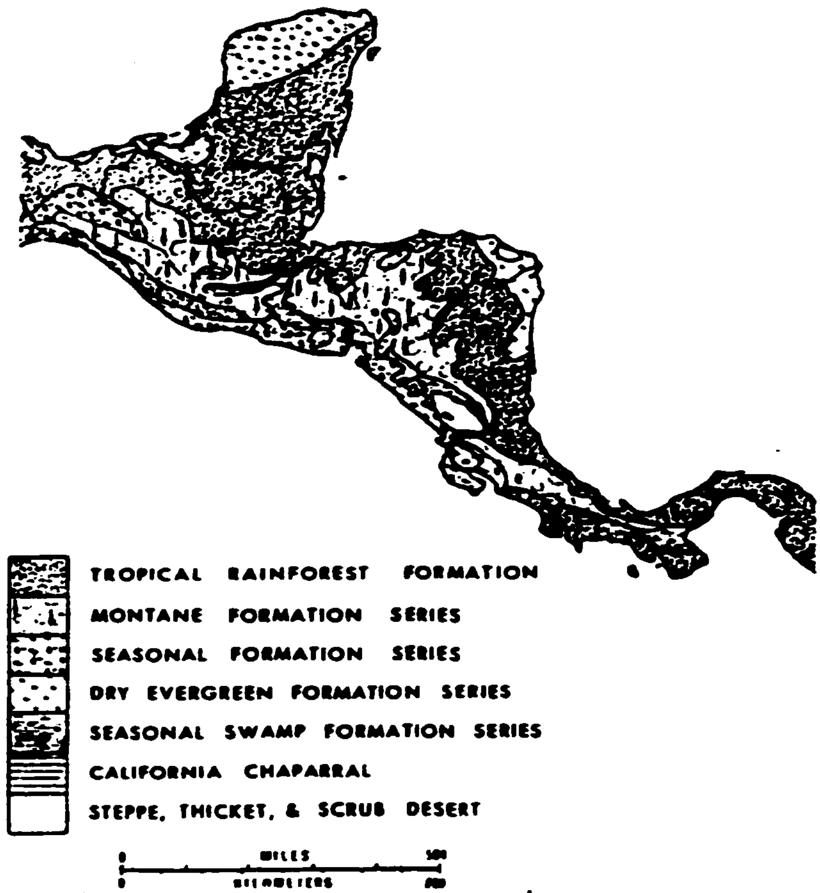


Fig. 48 Vegetation map of southern Mexico and Central America.

Fig. 49 Example of pine tree with large amounts of wood removed for *ocote* in Department of Totonicopán, Guatemala.

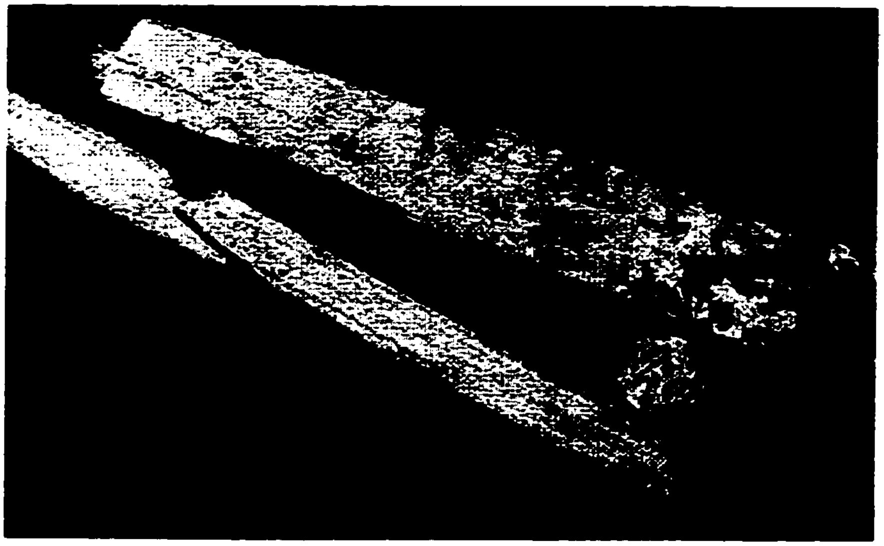


Fig. 50 Example of *ocote* from indigenous markets of Guatemala.

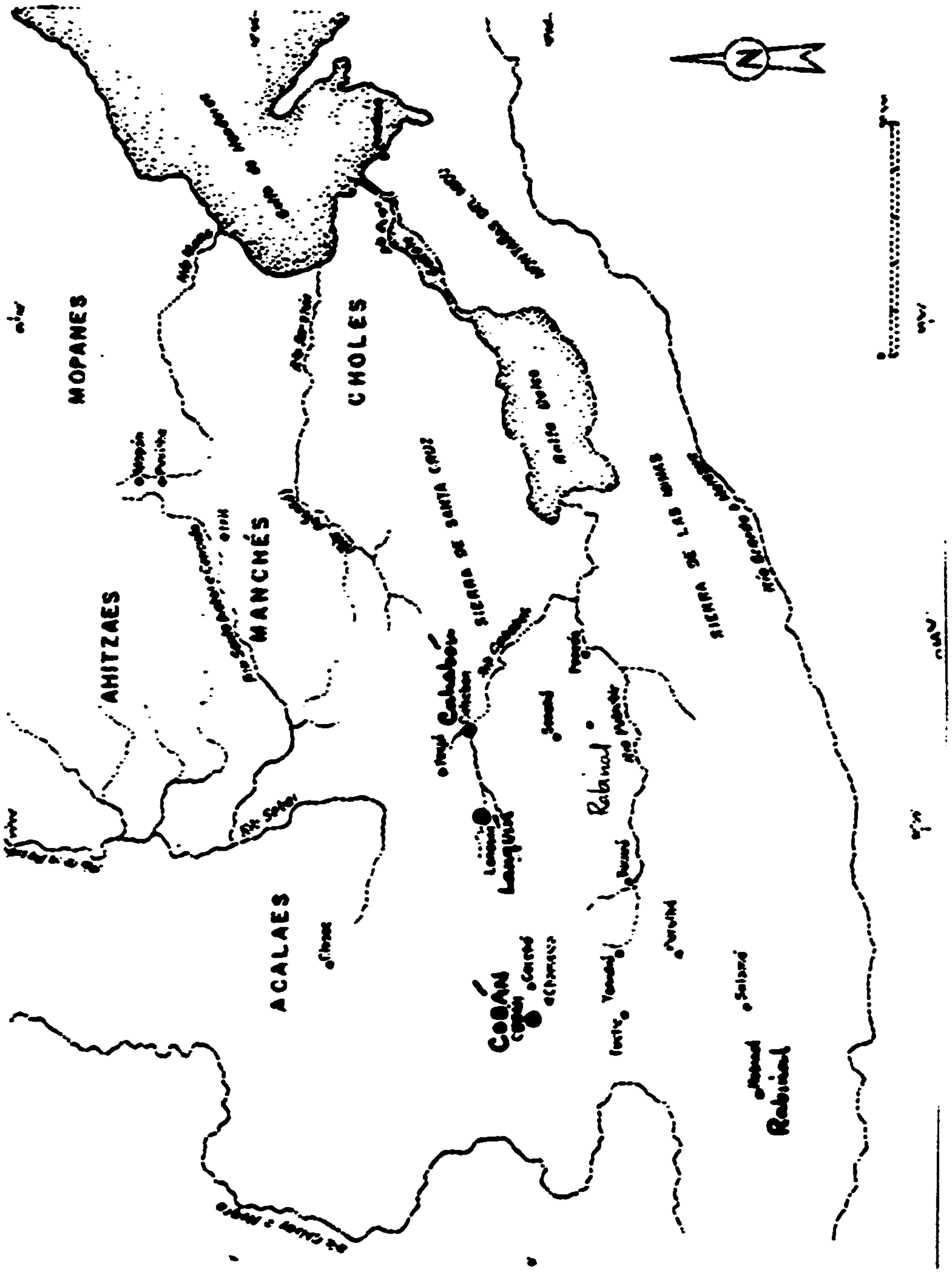


Fig. 51 Map of Alta Verapaz and environs. Lanquín is near center.

Fig. 52 Map of Guatemala with more important cities and features shown.

Fig. 53 View to eastern mountains from Lanquín. Note absence of natural vegetation due to forest clearing for milpa.

Fig. 54 Trunk of *Protium copal*, Burseraceae, Lanquín, Alta Verapaz, Guatemala.

a)

Fig. 55 Leaves of *Protium copal*, Burseraceae

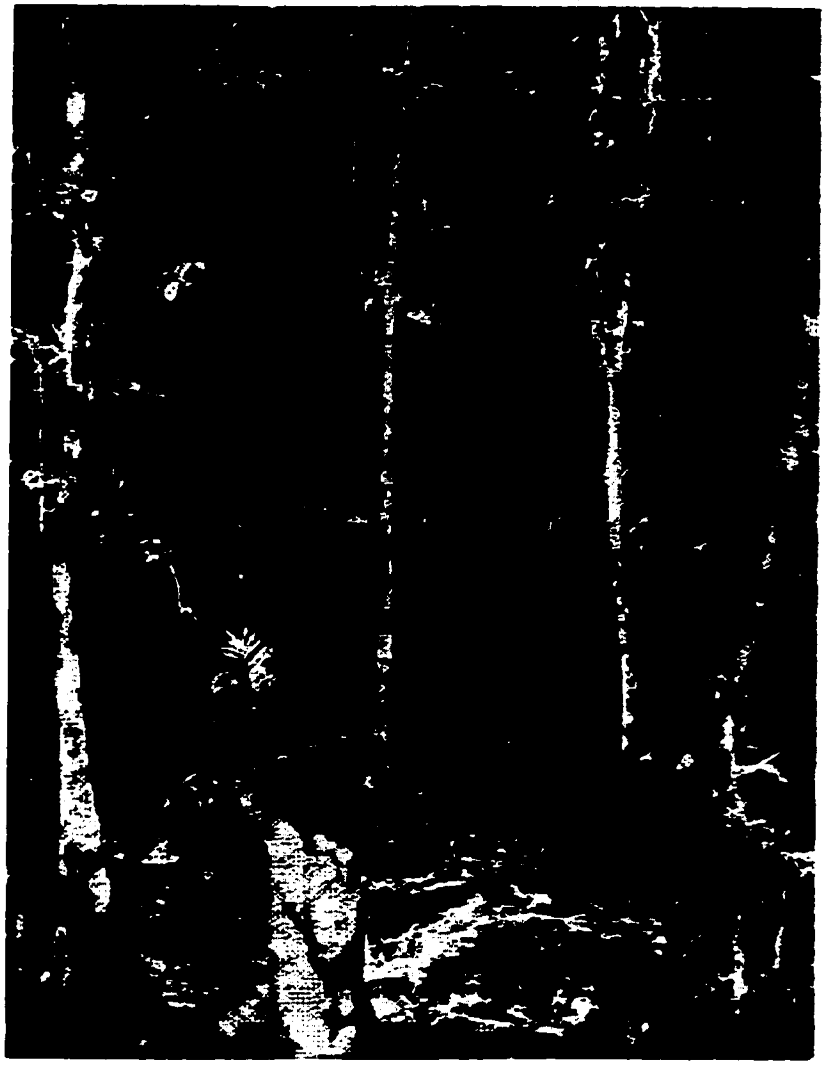


Fig. 56 Example of *Protium copal* trees growing on edge of roadside after selective clearing.

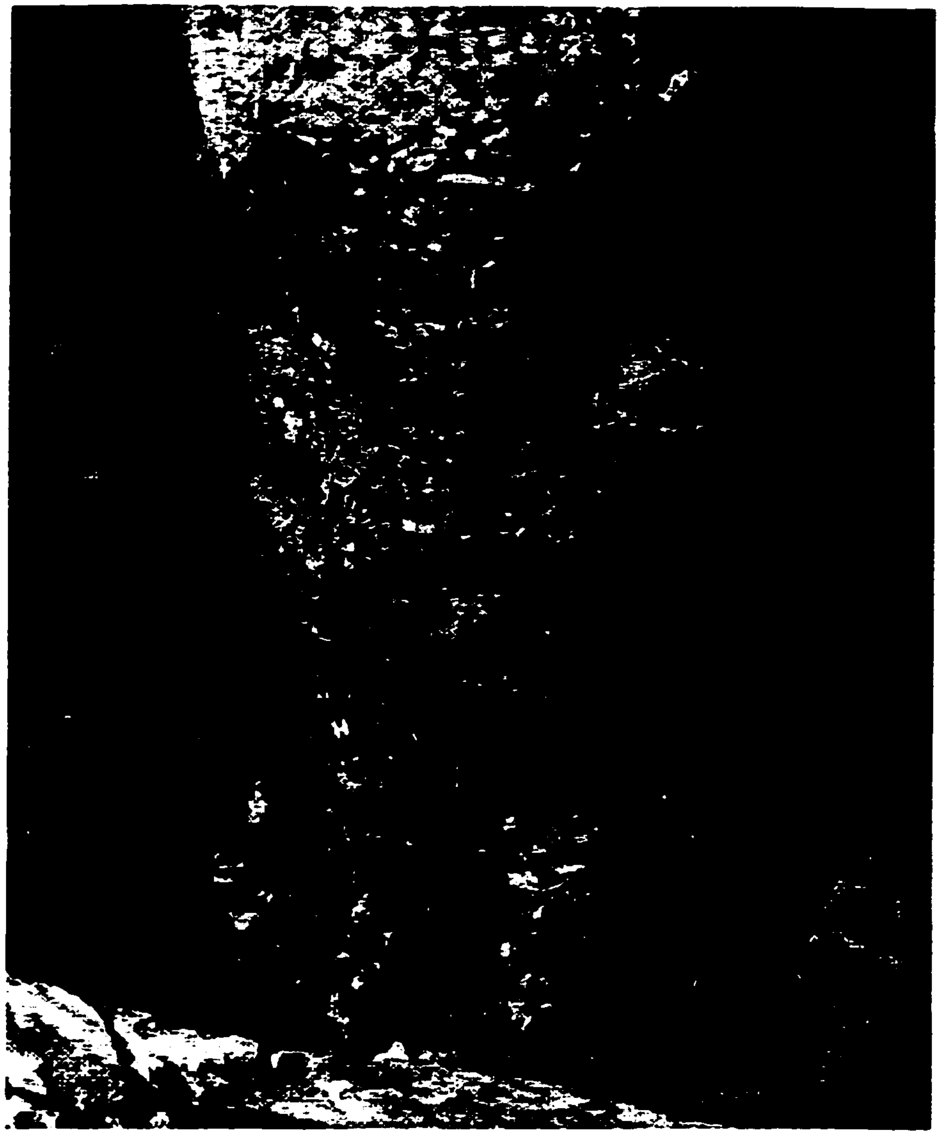


Fig. 57 Example of cuts made to *Protium copal* bark, see also Fig. 53.

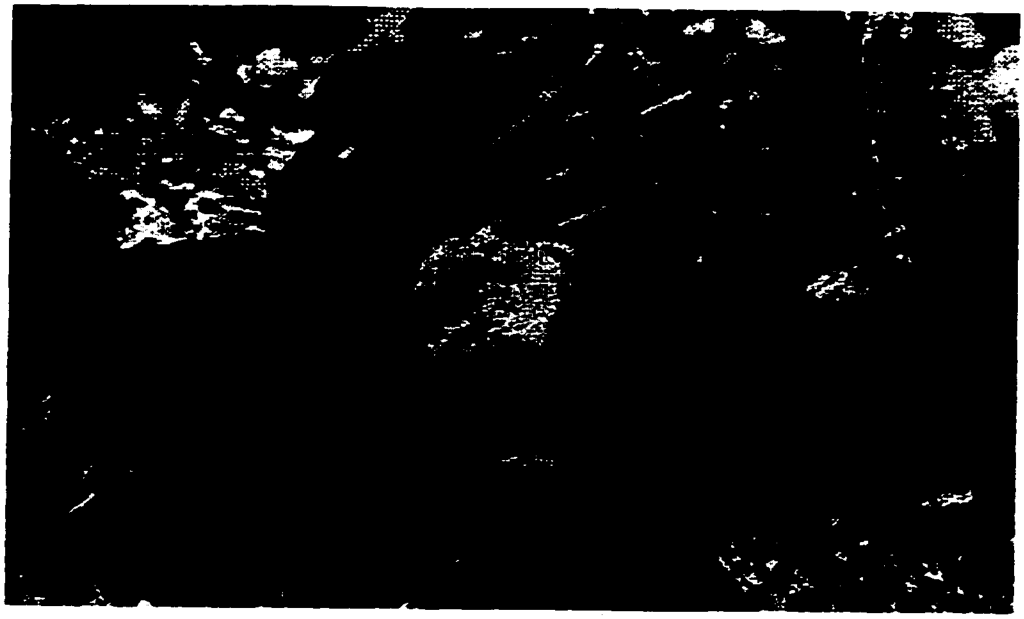
Fig. 58 Collection of resin from cut with knife and placement of exudate onto paddle.

Fig. 59 Paddle used to collect *Protium copal* resin.

Fig. 60 Rough molding of resin on paddle.

Fig. 61 Alternative application of saliva by collector to "keep the *pom* moist." Note cuts on tree trunk.

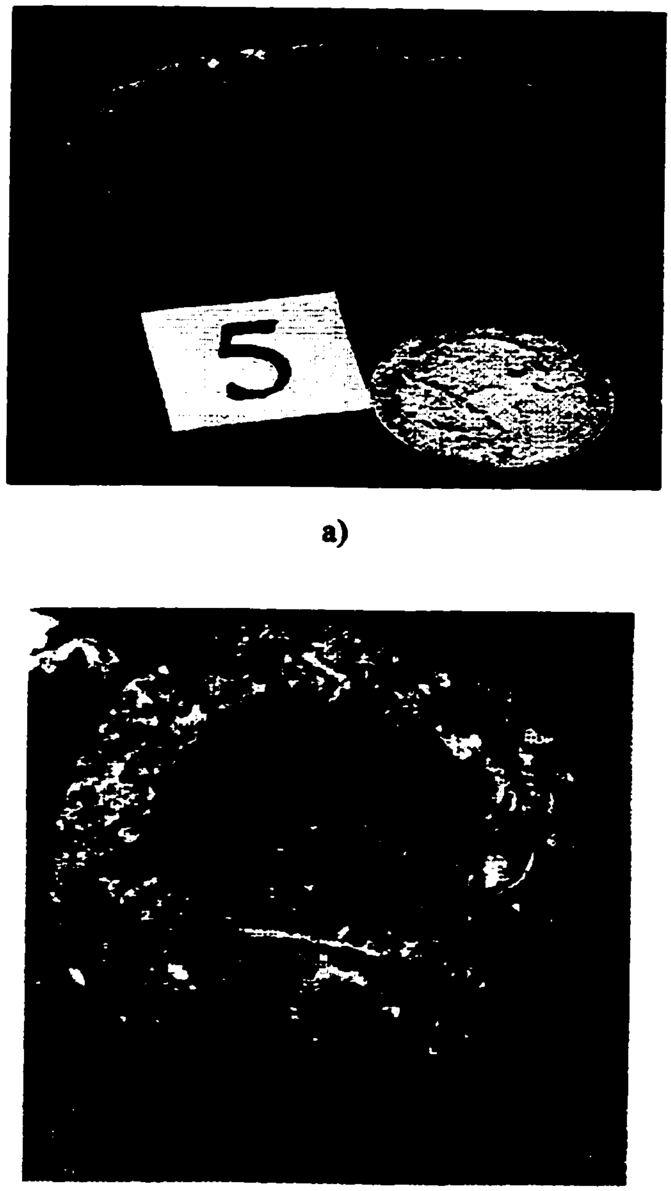
Fig. 62 Laying of resin upon cacao leaves, using paddle and knife. Note shape of knife.



a)

b)

Fig. 63 a) Shaping of resin mass b) Final packaged form of *Protium copal* resin in Lanquín.



a)

b)

Fig. 64 a) Exudate sample KT 5 b) One form of copal negro.

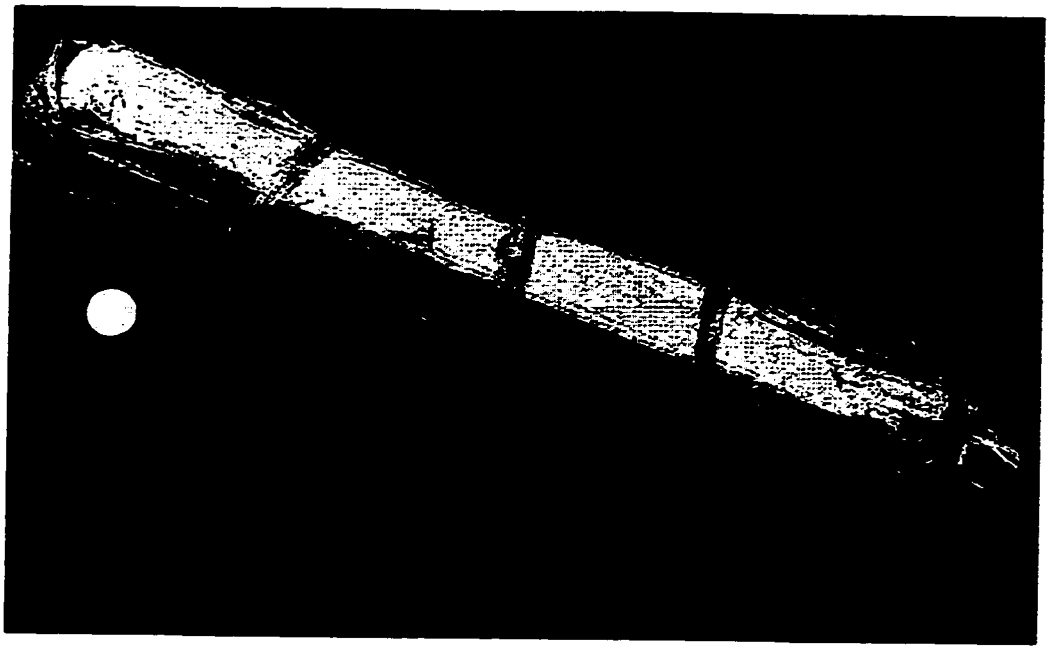


Fig. 65 Copal negro *tira* purchased in Canquixajá, Totonicopán, Guatemala.

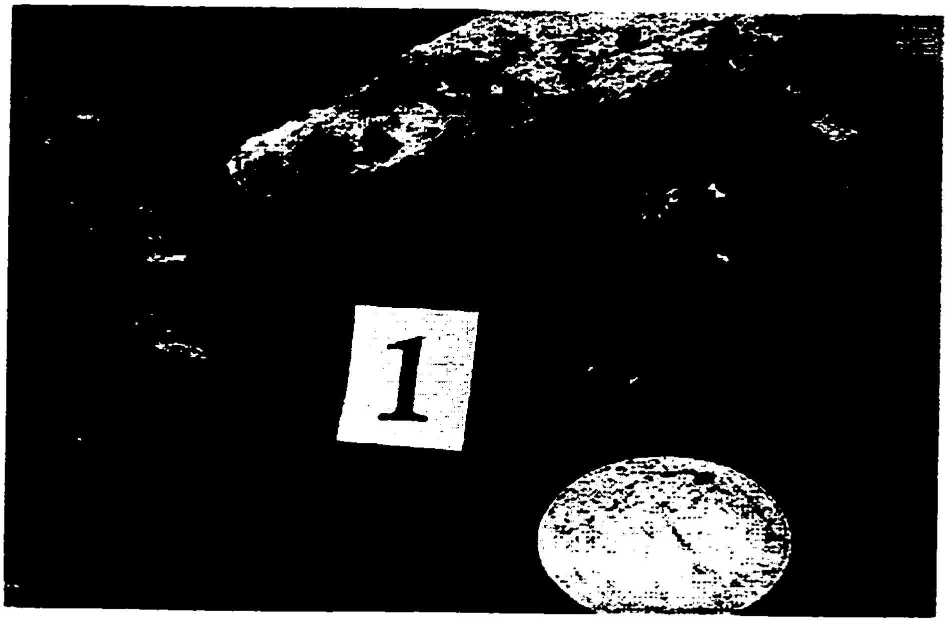
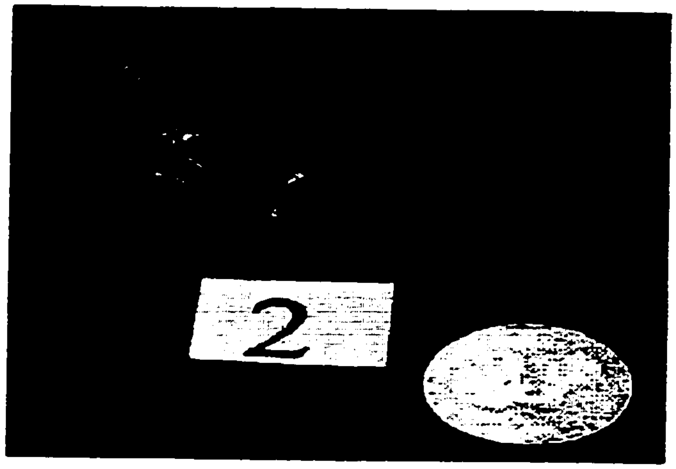


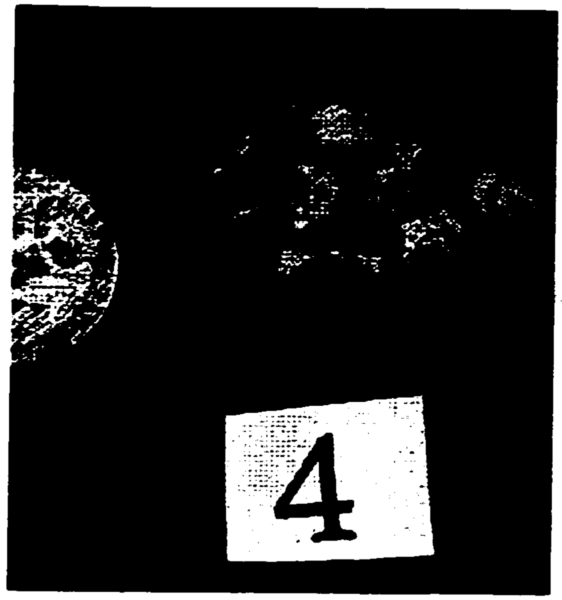
Fig. 66 "Estoraque"



a)

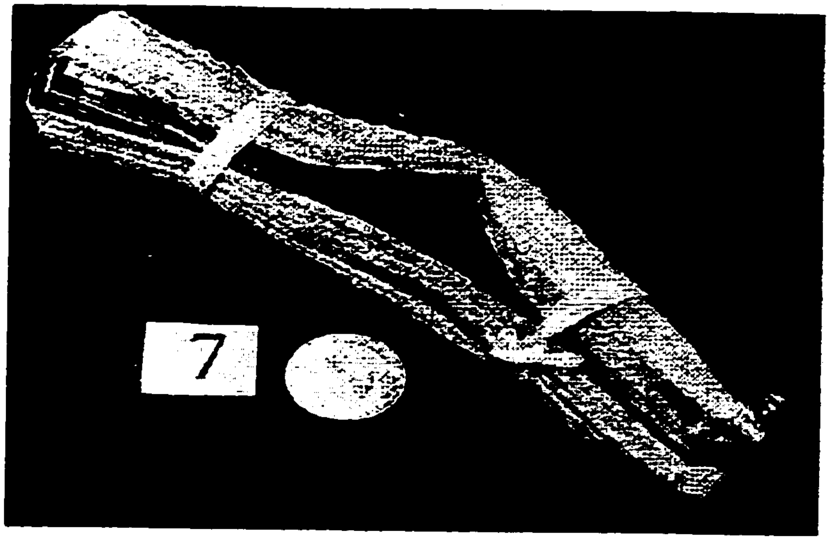
b)

Fig. 67 a) "Morambia," attributed by author to Pinaceae b) KT 3



a)

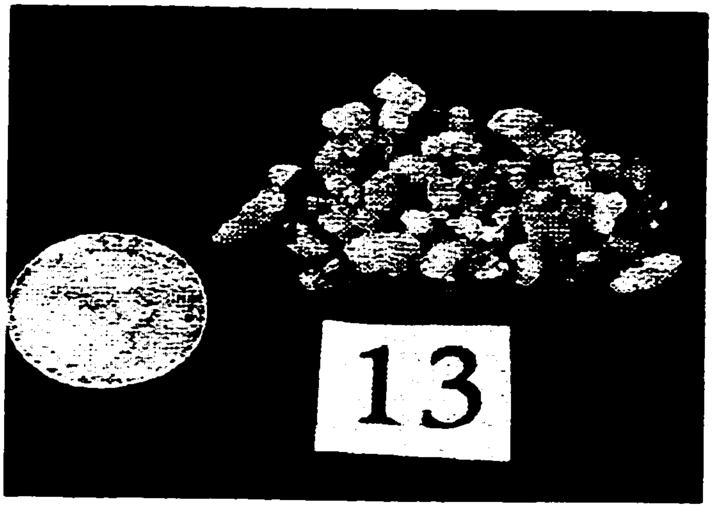
Fig. 68 a) "Incienso criollo," attributed by author to *Bursera copallifera*. b) "Copal amarillo," attributed by author to *Pinus caribaea* var. *hondurensis*



a)

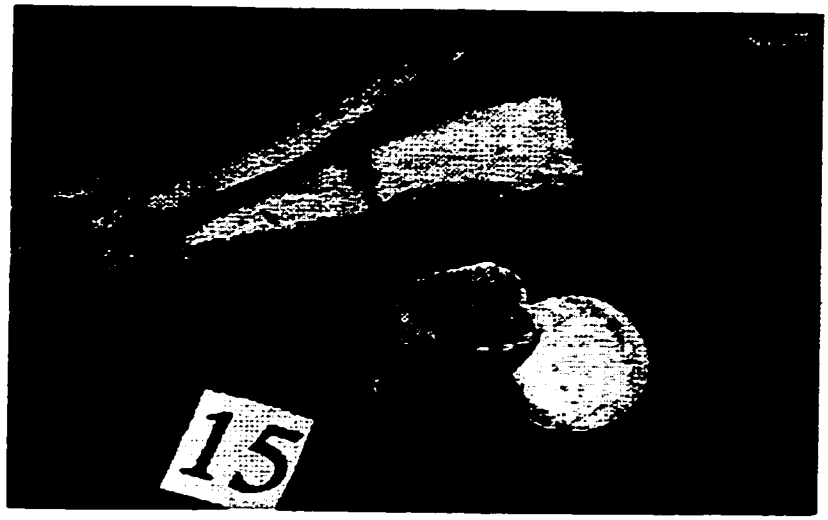
Fig.69 a) A smaller form of "copal negro", attributed to *Pinus* spp. by author. Note thin lozenge-like pieces within wrapper b) "Incienso negro," attibuted to *Pinus oocarpa* by author.

a)

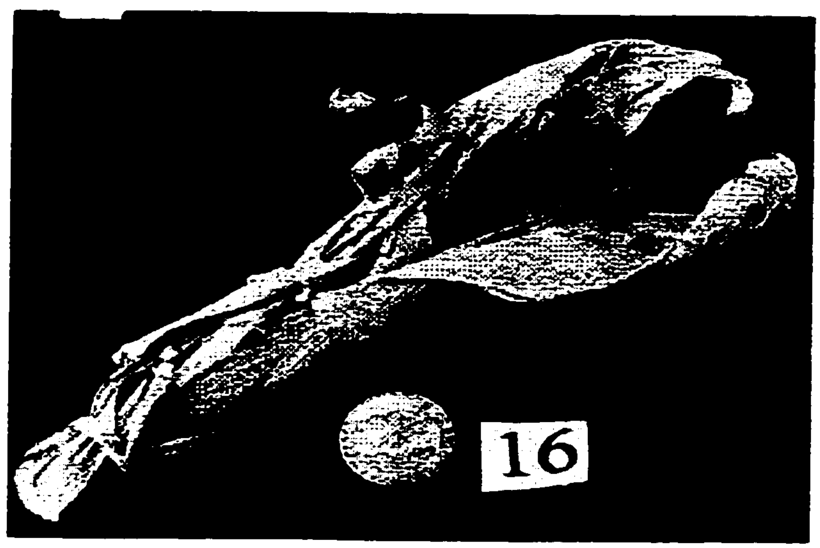


b)

Fig. 70 a) Attribution unknown b) Attributed to Burseraceae

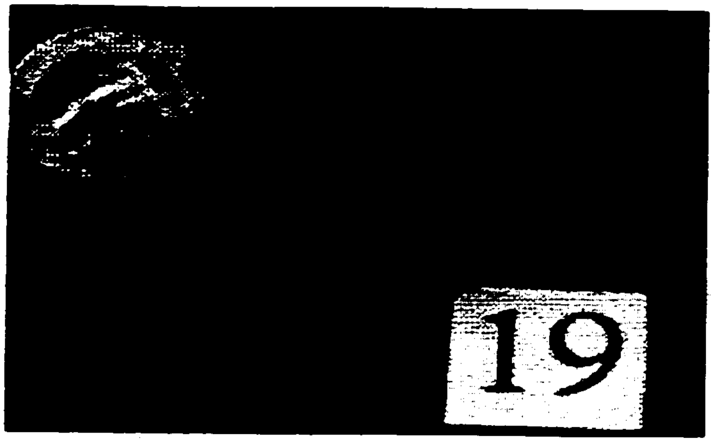


a)

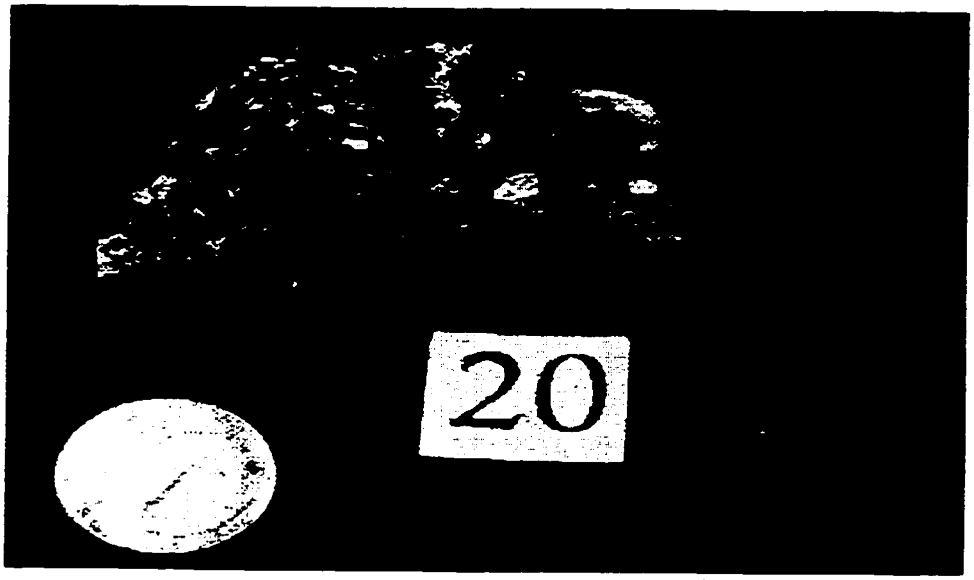


b)

Fig. 71 a) "Copal blanco," attribution unknown b) "Copal negro," attributed to Burseraceae or Pinaceae

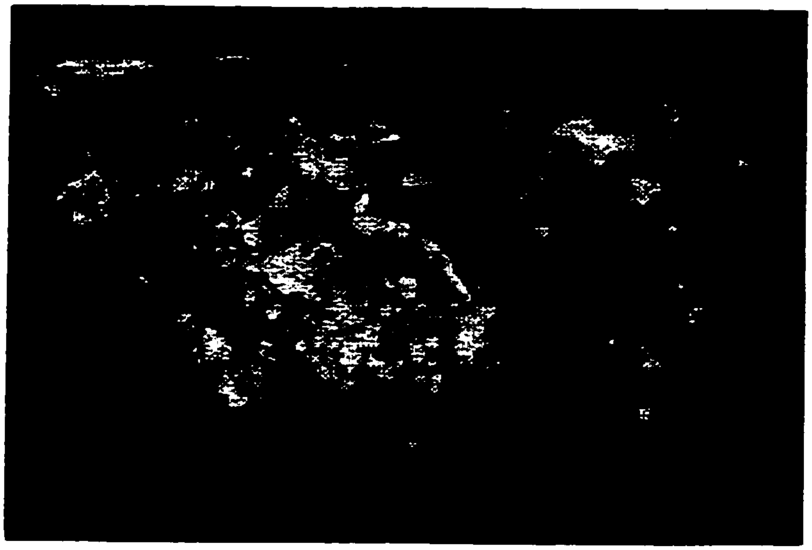


a)

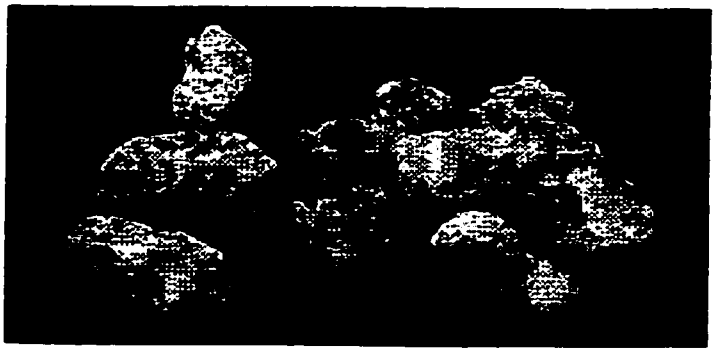


b)

Fig. 72 Yet another form of "copal negro," sold in ball form b) "Copal," attributed to Pinaceae by author.



a)



b)

Fig. 73 a) *Protium copal* resin after long exposure to air b) "Mexican frankincense," attributed to *Bursera copallifera* by author.

Appendix 1. Sources and uses of resin, balsam, and latex producing tree species encountered in the Colonial and modern ethnographic and botanical literature of central and southern Mexico and Central America

A signifies Aguilar (n.d.); AG is Aguilar Girón (1966); AD is Anderson and Dibble; AL is Alcorn (1984); AR is Arvigo (1994); Badi. is de la Cruz (1552, 1996); Berlin is Berlin *et al.* (1974); BL is Breedlove and Laughlin (1993); BM is Barrera Marin *et al.* (1976); C is Comerford (1996); Du is Duke (1985); EthnobotDB is Ethnobotany Database on WWW (1997, 1998) BM is Barrera Marin *et al.* (1976); F is Feldman (1985:80); GP is García Palacio (1985); H is Hernández (Books I and II, 1943), M is Martinez (1959 a or b); M. M. is Montero Miranda ([ca 1576] 1954); Mc is McVaugh and Rzedowski (1965); MO is Monardes (1925); Perry is Perry (1991); P & P is Peterson and Peterson (1992); R is Ramírez (1902); S is Standley (1946, 1982); SN & S is Soto Nuñez and Sosa S. (1995); T is Tozzer (1941); X is Ximénez (1967); Will. is Williams (1981)

* A indicates ancient use (preHispanic and 16th century; 17th to early 19th century; M indicates use in mid to late 19th and 20th century.

Italicized common names indicate an indigenous name, in constrast to Spanish or English names. The absence of proper wordprocessing symbols available to me prevented the use of correct lettering of Tzetzal plant names, as in the instance of Berlin *et al.*

The Nahuatl language is agglutinative. That is, words or names, are compounds, with the meaning and form of the root remaining unchanged. Martínez, in his *Plantas Utiles de la Flora Mexicana* (1943:177), states that the indigenous inhabitants of Mexico distinguish various species of copals, and that their names reflect a particular character or origin; the term 'copal' precedes or follows the descriptive term. For instance, *copalquahuitl*, or *patlahoac*, describes a copal variety with wide leaves. *Tecopalquahuitl* describes mountain copal, *xochicopal*, copal flower, and so forth.

All plant authorities are based upon Standley (1946, 1982) and Rzedowski and Guevara-Féfer (1992), and Index Kewensis On-line

Family	Genus and species	Common name	Uses and notes	Source	*
Anacardiaceae	*Cyrtocarpa procera* Kunth	*copalxocotl*, gummy plum tree,[1] *copaljocote*, *copalcocote*, *copali* [sic] (H), *chucumpuz*, *chungupo*, *chucumpu*, *chupandia* (Tarascan, Mich. & Gro.), varraco, *copaljocote* (Nahuatl, Gro.) (SN & N), copal (Guererro, Oaxaca), *pompoqua* (Tarascan) (H in S)	Unguent for fevers, admininstered against diarrhea and dysentary. Wood strong and longlasting, used to carve images of the gods and other carvings. Similar in flavor to *Bursera aloexylon* (H). Astringent juice extracted from trunk, and used to cure coughs. Infusion mixed with other barks[2] to cure queasiness and explosive dysentary. Infusion of bark, with that of *cuachalalte* (see *Bursera bipinnata*), used promptly to wash external wounds and	H (II:540-2); R (151); SN & N (59, 78, 95, 106, 112); S (1982:658-659, H, as cited in S, Thesaurus 82, 1651); M (1959b:154); Badi. (80-81, 138, F. 56 v.)	A M

[1] *Copalxocotl*, *copal*, incense, *xocotl*, ciruela (plum). Copal plum or plum oil and incense.

[2] Other barks: *Senna skinneri* (Benth.) Irwin et Barneby, "parácata," and *Lysiloma tergeminum* (both in Fabaceae). SS & N (1995:78)

Family	Genus and species	Common name	Uses and notes	Source	*
			sores. Masticated tannin-rich bark used for toothpain (SN & N); leprosy. "help for the traveler" (Badi.)		
Anacardiaceae	*Cyrtocarpa edulis* (T.S. Brandeg.) Standl.	*copalxocotl*, ciruela	Similar in form and properties to other kinds of incense, "encierran los huesos una almendra de buen sabor," effective as unguent against leprosy.	H (1943:542)	A
Anacardiaceae	*Pistacia mexicana* HBK.	*Pom k'an te* (Berlin), Copal *pom*, ramón, lentisco, resin known as almáciga (Oaxaca), *yaga-guieguei* (Oaxaca, Zapotec) (S), *tzajal paj-'ul*, "red sour corn gruel" (BL)	Dried plant sample, name supplied by collector; no uses given (S)	Berlin (292); Steyermark 50518 (8/13/42) in S (1982:661); BL (187)	M
Anacardiaceae	*Pseudosmodingium perniciosum* (H.B.K.) Engl.	*Quauhxiotl blanco*,[3] *cuajiote*, *copaljiote*, *cuajiote* blanco, *xiote* (S & M)	Bark cures itching. The juice of the shoots is effective against cough and hoarseness. Plant is poisonous and resin	H 1943:549-550); R. 1902:150); S (1982:664-665); M (1959b:497)	A

[3] *Cuauhxiotl*, *cuauh* X *cuahuitl*, tree, *xiotl*, itch???. Itch tree?

Family	Genus and species	Common name	Uses and notes	Source	*
			exuded by trunk has purgative properties. Rubbed upon skin to reduce pain of scorpion stings (R). M records this as a skin irritant		
Anacardiaceae	*Schinus molle* L.	Arbol del Perú, perú, molle, *copalquahuitl* (Nahuatl) (S) (R)	The "gum" is bluish white, acrid, and bitter and burns with a pleasant odor. Chewing gum. Also said to have purgative and vulnerary properties. Used as an emulsion to hinder development of cataracts, and used for genito-urinary and veneral diseases (S). Possibly cultivated (R.). Bronchial infections, genito-urinary illnesses (fruit extract), cataracts, corneal problems, wounds, strengthen gums and teeth,	S (1982:661-662; S also cites H (Thesaurus 54-55. 1651); R. (1902:147, 151); M (1959b:487-489, 1959a:261-265)	A

Family	Genus and species	Common name	Uses and notes	Source	*
			incense (M)		
Apocynaceae (latexes)	*Plumeria acutifolia* Poir.	*Cacaloxochitl* (Nahuatl), *cacalosúchil*, *súchil*, *suchlcahue* (Oaxaca), *tizacochitl*, *quie-chachi* (Oaxaca, Zapotec), flor de la cruz, flor de cuevo, flor de ensarta (El Salvador), sauanjoche (Nicaragua) (S).	Among favorite fragrant flowers of ancient and modern Mexicans, especially nobility. Church decorations, hair ornaments. Juice occasionally employed in treating wounds and venereal diseases. Said to produce good quality rubber (S).	S (1982:1150)	A M
Apocynaceae (latexes)	*Plumeria rubra* L.	*Cacaloxoxhitl*, *parandechicua* (Tarascan, Mich. & Gro.), *cacalosúchil* (Nahuatl, flor de cuevo, Gro.), rosa blanca (Gro.), candelero (Mich.), *cunda* (Tarascan?[4]) , *sabanicté*, *chacnicté*, *nicté* (Yucatek Maya), flor de mayo, flor de la cruz, *mammal peet* (AL)	"...[When cut] they have an exudation. Its exudation is white, sticky, adhering, like a resin. It is an adhesive, a filler" (AD). Caustic, milky latex popularly used for diverse skin problems, like ringworms, applied directly to skin (S &SN). Corollas said	AD (Book XI:205), SN & N (98); S (1982:1150-1151); Badi. (74-77, 136, F. 53 r.); AL (755-756)	A M

[4] *Cunda*, Tarascan, follwing León, as cited by Martinez (1979), in SN & N (1995:98)

Family	Genus and species	Common name	Uses and notes	Source	*
			to be used for coughs (S). "Contra la mente de abdera" (Badi.). Burns (AL). Cultivated.		
Apocynaceae (latexes)	*Tabernaemontana amygdalifolia* Jacq.	Pablillo (coasts of Mich. and Gro.), *t'abat'* (AL)	Branch latex extracted when moon is new, put onto cotton and stuffed into painful, decaying teeth (SN & N). Boils, loose teeth, dog bite, glue (AL). Cultivated.	SN & N (104); AL (803)	M
Burseraceae	*Bursera aloexylon* = *B. delpechiana*???	Linaloe, *xochicopal* (Oaxaca)	Cure for scorpion stings, neuralgia, and as incense.	M (1959b:367-370, 1959b: 448-9)	
Burseraceae	*Bursera bipinnata* (Sessé & Moc. ex DC.) Engl.	Copalillo, copal, *tzon nsue ntka, 'palo tetlate'* (Oaxaca, AL); *ach'el pom, tzo'ka' pom*, mud pom (Tzotzil, BL, Tzetzal); copal, copal chino (SN & S), copal *pom, pom, copal, copalán*, copal santo (Guatemala)	Considered an occasional "cultivated" plant. Trunk for firewood and incense, ingredient in "flower water" for adults and newborns. A "hot" tea prepared with thirteen splinters of wood and gunpowder; for a	Berlin (292); BL (179;437); Tapia Garcia[6]; SN & S (94, 101, 111, 122, 420, 442), S (1946 (24, V):436-437)	M

Family	Genus and species	Common name	Uses and notes	Source	*
			loose tooth, thirteen splinters brewed with another wood (*Quercus rugosa*), drunk before breakfast, swellings (BL); part of a preparation used to bathe newborns; bark is cut, heated, used to treat rheumatism; fresh fruits are taken with water for "hinchado de nacido" (boils?). Unripe fruits of this small tree are eaten to cure rashes. Bark of tree used in curative baths against "cold"[5] (SN & S).		
Burseraceae	*Bursera copallifera* (DC.) Bullock (=*B.*	Copal, copal chino (Mich. and Gro.)	Boiled branches of tree used alone or in	SN & S (102, 111, 122); H	A M

[5] The bark, along with that of *cuachalalte* (*Amphipterygium adstringens* (Schldl.) Schiede, Julianaceae), is macerated in water. (SN & S 1995:101).

[6] Tapia Garcia, 1985, *Las Plantas Curativas y su Conocimiento Entre Los Amuzgos; Árboles Grandes y Arbustos* (CIESAS, Mexico), provided by Nick Hopkins, Aztlan List-serve, 8/8/98. Source not located.

Family	Genus and species	Common name	Uses and notes	Source	*
	jorullensis Engl.)	*Copalquahuitlpatla-hoac*[7], árbol de copalli latifolio, copal blanco, copal, copal santo, goma de limón, copal de penca,[8] *copalcuahuitl*	combination with other "hierbas del aire," to relieve "dolor del aire." Taken orally or as curative baths (SN & S). White, high quality, but in lesser quantities than *Bursera aloexylon*, incense. Glossy varnish, uterine diseases, bark employed in tanning and dyeing. Modern commercial incense. Scaling wax, medicinal unguents, uterine problems. Scabies (Badi.=*B. jorullensis*).	(:534); (pers. observ.); M (1959b:176-179, 1959a:399); Badi. (18-19, 141, F. 8 v.)	
Burseraceae	*Bursera discolor* Rzedowski	*Guande*, guande verde (Tarascan, Mich. and Gro.), jiote, jiote verde (Nahuatl, Mich. and Gro.), pega hueso	White, thickset resin occasionally used in country as poultice to hold broken bones in place and cuts	SN & S (94, 102, 111, 125)	M

[7] Nahuatl: *Copalquahuitlpatlahoac*: *copal*, incense, *cuahuitl*, tree, *patlahuac*, wide (as in leaf width).
[8] According toa note in Hernández (1943:534) and Martinez (1943:178), the resin of this tree was often collected in maguey leaves, hence the common name "copal de penca."

Family	Genus and species	Common name	Uses and notes	Source	*
		(Mich.), copal (Mich. and Gro.) (SN & S)	together. Applied directly for cleaning wounds, as poultice for scorpion bite and to counterract venom (SN & S).		
Burseraceae	*Bursera diversifolia* Rose	Copal, *copal pom hembra* (Guatemala)	Bark or branches constitute one of "hierbas del aire," mentioned in *Bursera heteresthes* and *B. sarukhanii* (see section below). For ill-defined morbid states, bark, branches and leaves taken orally or in curative baths (SN & S).	SN & S (122, 147); S (1946: (24, V) 437)	M
Burseraceae	*Bursera excelsa* (H. B. K.) Engl., DC	*batz'i pom, muk'ta pom, pom ryox*[9] (Tzotzil), *copal*, incienso, copalillo real, copal de tecomajaca, tecomajaca, campón	Fencerows, trunk slivers used as incense, wood splinters brewed with gunpowder for swelling, "hot" splinters used as basic ingredient of	Berlin (592); BL (179, 420, 442); S (1946: (24, V) 437-438)	M

[9] Tzotzil: *batz'i pom* is "genuine" pom, *muk'ta pom* refers either to the Tzotzil term for "large" or to Muk'ta Jok', a Tzotzil town and, *pom ryox* may refer to red, as the term does in other Maya languages.

Family	Genus and species	Common name	Uses and notes	Source	*
			"flower water." Considered to be a "cultivated" agricultural plant (BL), hedges, local use as varnish (S).		
Burseraceae	*Bursera grandifolia* (Schldl.) Engl.	Unknown	Resin applied directly or as poultice for wounds.	SN & S (94)	M
Burseraceae	*Bursera graveolens* (H. B. K.) Triana & Planch	*kaxiy tsakah* (Huastec)	Systemic disease medicine. Leaf and sap of tree applied for headache. Cultivated by Huastec Maya.	AL (569)	M
Burseraceae	*Bursera heteresthes* Bullock	Copal, copal blanco, copal santo, copal de santo (Mich. and Gro.).	Boiled branches and leaves of tree used alone or in combination with other "hierbas del aire," to relieve "dolor del aire." Taken orally or as curative baths. Resin as poultice for broken bones, cleansing solution for wounds in humans and livestock, and uses similar to *B. sarukhanii* and *B.*	SN & S (102, 111, 122, 147)	M

Family	Genus and species	Common name	Uses and notes	Source	*
			hintonii (SN & S)		
Burseraceae	*Bursera hintonii* Bullock	Copal blanco, copal de cristal, jaboncillo (Mich.), *tecomaca* (Nahuatl, Gro. and Mich.)	Unripe caudiflorous fruits of this tree are frequently used to cure cough. Bark for external lesions.	SN & S (57, 147)	M
Burseraceae	*Bursera microphylla* (A. Gray) Rose	*Copalquahxiotl*;[10] torote, torote blanco, copal, *cuajiote* colorado, elephant tree	Resin similar to *copalli* in flavor and odor, but scanty. Diluted with water, said to be extraordinarily effective against diarrhea (H). Bark used for tanning and dying (AL, Mab). Venereal diseases, lacquers, varnish, incense (M).	H (:546); M (1959a:498-499, 1959b:178-9)	A M
Burseraceae	*Bursera odorata* (T. S. Brandeg.) Rose.	*Cuitlacopalli*,[11] cuiajote verde, torote, chutama	White, very aromatic and hard[12]. "...Sometimes called *xioquahuitl* because...trunk seems to attack leprosy,"	H (544-5); M (1959a:470, 1959b:180)	A M

[10] Nahuatl: *Copalquahxiotl*, *copalquahuitl*, copal tree, *xiotl*, itch??? Itchy copal tree???

[11] Nahutal: *Cuitlacopalli*, de *cuitla* (*tl*), dung, manure, and *copalli*. "Copal of the muck-heapers (S).

[12] In contrast to Hernández' observation, Standley's description states that the resin is yellow, brown, or black, without odor, acidic and bitter, and is used in traditional medicine as an expectorant and purgative (H:1943:435).

Family	Genus and species	Common name	Uses and notes	Source	*
			applied to insect bites (H). Dropsy, dysentary, venereal diseases, sudorific, purgative, diuretic, adhesive (M).		
Burseraceae	*Bursera sarukhanii* Guevara et Rzedowski	Copal, copal de santo, copal blanco	Resin used for treatment of pneumonia,[13] resin is applied as poultice to navel[14] to cure urinary incontinence in large children "(encuresis nocturna)." Bark and leaves for infusion for "dolor del aire;" expectorant, purgative, cure for scorpion stings (Mab).	SN & S (57, 82, 102, 122, 147); Mab (91)	M
Burseraceae	*Bursera simaruba* (L.) Sarg.	*Cachibou*, Gomant resin, gumbo limbo; Mulato or "indio desnudo," *tzajal*	Bark and leaves taken orally or as curative baths for	Berlin (592); SN & S (147); BL (153, 420),	M

[13] The resin is powdered and mixed with a lukewarm egg and taken simultaneously with a base made from bálsamo de palo (*Myrospermum frutescens* (Jacq.) and the bark of chirimoya (*Annona cherimola* Miller). SN & S (1995:57)

[14] Or, could this be the urethral opening?

Family	Genus and species author.	Common name	Uses and notes	Source	*
			can be extracted. Its water is potable; it calms one, it gladdens one (AD)."	350, as cited in AD	
Burseraceae	*Bursera trijugum* (Ramirez) Rose	*Copalli tototepecense*, Nahuatl, recent: *cuajiote* chino	Cures fevers, dysentary, and diarrhea (H).	H (540)	A
Burseraceae	*Bursera spp.*	*Tecopalquahuitl*,[16] *copalli* del monte, *xochicopal*, *cuajiote* colorado, *cuajiote* amarillo, *Tecopalquahuitl pitzahoac* or tenuifolia (S), *tzihuac copalli* , *quauhxiyotl*, *iztacquahxiotl* (Badi.), anime?	Somewhat astringent, smoke strengthens the stomach, heart, and uterus, reduces discharges, mucous, keeps cold away from fevers, warms cold parts of the body, restores fallen wombs, and resulting despondency (H). Varnish, domestic medicine (S). Mixed with ant dung or that of childrens'?, and taken two or three times in one ounce doses, is said to cure that those are delirious without fever (H), tannins	H (:536); S (1946 (24, V):435, Badi. (68-69, 134, F.48 v., 64-65, 146-147, F. 45 r.)	A M

[16] Nahuatl: *Tecopalquahuitl*: *te*, -tl prefix for stone, *copal*, incense, *cuahuitl*, tree. Copal tree or stone incense.

Family	Genus and species	Common name	Uses and notes	Source	*
			heartburn and heartpain, "hot" tea for "wind" (chills and fever, swelling), leaves for "steam cures" (BL).		
Burseraceae	*Bursera tecomaca* (DC.) Standl.	*Tecomahaca*, torote, tecomaca (S)	Bitter and fragrant. "Endowed with same properties as, and used in place of, myrrh. Soothes pain caused by flatulence and cold, benefits uterus, strengthens stomach and relieves ulcers." Calms nervousness, toothaches, tones the brain and weakened nerves (H). Said to cure wounds, sores (S). Plasters reduce swellings, any "cold" illness, orifice seepage, tooth ache (MO).	H (:553); MO (I:13-15)	A
Burseraceae	*Bursera tomentosa*	*Pom*	Incense.	Berlin (292)	M
Burseraceae	"*Bursera multiugum, Bursera odoratum*"	*Quauhxiuhtic*, Nahuatl	"It is tender, very tender. It is [a plant] from which water	AD, Book XI, p. 192; Garibay ed., Vol. IV, p.	A

Family	Genus and species	Common name	Uses and notes	Source	*
			heartburn and heartpain, "hot" tea for "wind" (chills and fever, swelling), leaves for "steam cures" (BL).		
Burseraceae	*Bursera tecomaca* (DC.) Standl.	*Tecomahaca*, torotć, tecomaca (S)	Bitter and fragrant. "Endowed with same properties as, and used in place of, myrrh. Soothes pain caused by flatulence and cold, benefits uterus, strengthens stomach and relieves ulcers." Calms nervousness, toothaches, tones the brain and weakened nerves (H). Said to cure wounds, sores (S). Plasters reduce swellings, any "cold" illness, orifice seepage, tooth ache (MO).	H (:553); MO (I:13-15)	A
Burseraceae	*Bursera tomentosa*	*Pom*	Incense.	Berlin (292)	M
Burseraceae	"*Bursera multiugum, Bursera odoratum*" ***Nedd	*Quauhxiuhtic*, Nahuatl	"It is tender, very tender. It is [a plant] from which water	AD, Book XI, p. 192; Garibay ed., Vol. IV, p.	A

Family	Genus and species	Common name	Uses and notes	Source	*
		sal-te', "red scaly tree" (BL), palo retinto, (Mexico) *jiote*, chino, *chinacahuite*, palo jiote, *solpiem, cajha, xacago-que*, palo chino, *chacah, chach colorado, chacá,*, palo mulato, indio desnudo, *chic-chica, cacah*, gumbo limbo, birch, copón (S); *chacajiota,cojuite, huk'up, lon-shala-ec, tzaca, tusun ta'sun, palo retinto, zongolica, yala-guito*, almáciga, (M), *tsaka* (AL)	skin infections and wounds, internal parasites, respiratory problems, and dysentary (S & SN). Considered occasional "cultivated" plant, three chips of bark chewed for loose teeth. For "white dysentary," four chips are brewed, hot bowl of "tea" drunk before breakfast, may also be taken for cough. Chips pounded and soaked in cold water for bloody dysentary, sometimes mixed with *Guazuma ulmifolia* ("hot"). Infusion is "cold." In 1797, Zinacantan priest reported that this tree was used to	S (1946: (24, V) 439-441); MO ((I) 12): C (332-333); AL (569-570); AG (363)	

[15] Alcorn states that two varieties of *B. simaruba* are recognized by the Huastec Maya of Mexico; the bark remedy for fever is classified as very cold (Alcorn 1984:569-570).

Family	Genus and species	Common name	Uses and notes	Source	*
			fever (H), tannins and dye, and possibly for venereal diseases (S). "Cuando se hincha la vena pinchada" (Badi.)		
Burseraceae	*Protium copal* (Schlect. & Cham.) Engl., DC	*Pom*, *copal pom*, *pumu* (Zinca), *pom* (Kakchikel and K'iché), *yalahpom* (crude copal), *chakihpom* (dried copal), *hok*, *pixtun* (copal rolls), *mukmuxcay* (copal burned in braziers) (F), *pom*, *chom*, *copal*, *pom-te* (S), *homte'* (AL)	Incense respiratory problems, vermifuge, antiparasitic, styptic, topical wound binder, masticatory (Guatemala). Smoking of idols in preHispanic period, smoking of saints in colonial period, chewed (X, see also salsafras below), "principle source" of copal, varnish, medicine. Upset stomach, internal parasites, evil spirits and spiritual diseases. Fumigate body with smoke to expel illnesses, resin on joints for rheumatism, toothache (C). GI	BM; F (80); X (245-246); AR (187); C (333); AL (763-764); S (1946: (24, V) 442)	A M

Family	Genus and species	Common name	Uses and notes	Source	*
			pain, child's stomach problems, vomiting, fright, dizziness, earache, to sicken others, incense, ritual. Cultivated (AL).		
Burseraceae	*Protium schipii* Lundell	Copal macho, *pom*	Incense (Yucatán)	BM; S (1946: (24, V) 443)	A M
Burseraceae	*Protium* spp.	*Pom*	Incense.	T (75 n.338)	A M
Clusiaceae (latex)	*Calophyllum chiapense* Standl.	Leche de Maria	Wounds.	Common name given by X (1967)	C
Euphorbiaceae (latex)	*Croton alamosanus* Rose	Ocotilo (Sinaloa)	Toothache remedy.	S (1982:618)	M
Euphorbiaceae	*Croton cortesianus* H. B. K.	*Ek balam, xabalam* (Yucatán), *puthwal* (AL)	"Juice" applied as caustic treatment for skin diseases (S). Stomach, GI pain, diarrhea, venereal sores, gonorrhea, itchy sores, wounds, "sap" speeds healing, eye infection, reduction of menstrual bleeding, screw worms in animals (AL).	S (1982:618); AL (614-615)	M P
Euphorbiaceae	*Croton draco*	Sangre de draco	Wounds and eye	Berlin (177-	M

Family	Genus and species	Common name	Uses and notes	Source	*
	Schlecht.	(Veracruz, Chiapas, Oaxaca, Guatemala), *cic' hat* (Tzetzal, Berlin), *tlachinole*, sangregado (Veracruz), *ezquahuitl* (*Nueva Farmacopea Mexicana*), *xiixte'* (AL)	wounds (Berlin). Bitter blood-red sap employed as remedy for hoof diseases in burros and horses (S). Wood host to edible fungus, toothache, sores, fuel, firewood (AL).	180); S (1982:615); AL (:615)	
Euphorbiaceae	*Croton morifolius* Willd.	*Cic' hat* (Tzetzal, Berlin), Palillo (Oaxaca, Michoacan)	Contains an essential oil, which applied externally, relieves neuralgia. Inhalations of oil is said to result in insensibility and paralysis. An infusion of leaves drunk for pains in the stomach.	Berlin (177); S (1982:620)	M
Euphorbiaceae	*Croton stipulaceus* H. B. K.	Unknown	Unknown	F (80)	A
Euphorbiaceae	*Croton xalapensis* H. B. K.	Chirca (Guatemala, Honduras)	"Gum" exuding from trunk is used to clean teeth.	S (1982:618)	M

Family	Genus and species	Common name	Uses and notes	Source	*
Euphorbiaceae	*Euphorbia calyculata* H. B. K.	*Chupire, chupireni* [17](Tarascan, Michoacán), *tencuanete*.	Although milky juice causes blisters and inflammation of skin, residents of Michoacán used plant for venereal diseases (H in S).	S (1982:599)	A
Euphorbiaceae	*Euphorbia cotinifolia* L.	*K'an cu wamal* (Tzeltal, Berlin), Trompillo, piñoncillo, mala-mujer (Oaxaca), mata-gallina (Veracruz), hierba mala (Guatemala), sapo (Nicaragua).	Milky sap has violent emetic-cathartic properties, and is poisonous even in small doses (S).	Berlin (177-178)S (1982:603)	M
Euphorbiaceae	*Euphorbia pulcherrima* Will.d.	*Séla nicin* (Tzeltal, Berlin), *Cuitlaxochitl* (Nahuatl), flor de Pascua (ubiquitous), flor de Santa Catarina (Oaxaca), poinsettia, *oot' wits* (AL)	Ornamental (Berlin). It has an exudation, a resin (AD). Milky juice employed by Indians to remove hair from the skin (S)[18]; antiodontalgic, emetic, depilatory, in Guatemala (Duke). Vaginal hemorrages, snakebite (AL).	Berlin (208); AD, Book XI:203; H, Vol. III, p. 958; S (1982:600); Duke (190); AL (650)	A
Fabaceae	*Hymenaea courbaril* L.	Cuapinole, Sausage Tree or Stinking Toe	Glue, varnish, folk medicine (A);	Aguilar; EthnobotDB; M	A

[17] *Chupireni*, "that which burns."

[18] This is stated by Grosourdy, as cited in Standley.

Family	Genus and species	Common name	Uses and notes	Source	*
		(Huasteca); goma animé, ambar guapinole[19], incienso de tierra (Aguilar); ambar de cuapinole, incienso de cuapinole, *nere* (Oaxaca, Zapotec), palito colorado, copinol, palo colorado, *pacay* (Petén), *pac* (K'eck'chi), *pacoj* (Baja Verapaz) (Guatemala, Honduras), known in trade as South American copal (S); *chilim te'* "powdery tree," (Tzotzil, BL), *vchmalanché* (Kakchikel), hoja de cuchillo (Jutiapa, Guate.), guapinol, cuapinol, copinol, palo colorado, temá, hoja de chuchillo, *pacay*, *pac*, *pacoy*, copal (Will.)	occasionally burned as incense in temples, manufacture of varnishes (Aguilar). Used in treatment of asthma, catarrh, purgative, rheumatism, sedative, sores, venereal diseases (Mex.), malaria (Honduras); varnishes, purgative properties, vermifuge (as cited in Martinez); fruit pulp used to make a type of atole and said to be fermented to produce an alcoholic beverage. Incense in churches, varnish. Said to be exported to Brazil[20]. A decocotion is	(1943:188-191); S (1946 (24, V):141-142), (1982:413); BL (153); Will. (153); Ag (363)	

[19] According to Martinez (1943:188), the name is derived from Nahuatl: *cuauhpinoli*, *cuauhitl*, tree, and *pinoli*, powdered toasted maize, "tree of powdered maize."

[20] Langenheim indicates that Brazil has many species of this genus and that it is the center of distribution of the genus (personal communication). Standley's comment is odd in light of this fact.

Family	Genus and species	Common name	Uses and notes	Source	*
			reportedly active as an arterial sedative, and to have purgative and carminative properties, quinine substitute in Honduras (S). Bark decoction is vermifuge (AG).		
Fabaceae	*Myroxylon balsamum var. pereirae* (Royle) Harms	Balsam of Peru, bálsamo (Veracruz, Chiapas, Guatemala), bálsamo de Peru, *hoitziloxitl* (Nahuatl), *chuchupate* or palo de trapiche (Martinez), *nabá* (Yucatán, Tabasco, Maya), *chucte* (Veracruz), semillas del obispo, cedro chino (Oaxaca), *yaga-guienite* (Oaxaca, Zapotec), balsámo negro	It is of pleasing odor, perfumed (AD). Perfumes and medicines, especially in Spain. Oleoresin used as tribute item in past, and, medicinally, against asthma, catarrh, rheumatism, gonorrhea (boiled leaves), diuretic and anthelmintic. Medicine par excellence (H); female cosmetic (GP), stomachic, expectorant (S). Reduces shortness of breath, diseases of the bladder, and	AD, Book XI, p. 192; H (II:558); X (244); GP; S (1946 (24, V):306-308, 1982:433-434); MO (I:23-27). Central American uses not found in EthnoDB; GP; M (1959a:47-49, 1959b:66-71); AR (185); A (362)	A M

Family	Genus and species	Common name	Uses and notes	Source	*
			provokes menses, stomachic, relieves liver problems, cold humors, winds, swellings, vulnerary, styptic, etc. (M). Cold, bloody diarrhea, scabies, syphilitic ulcers, gonorrhea. Bark tea for all conditions of urinary tract, prostate, liver, inflammation. Balsam is respiratory stimulant. Oil for wounds and ulcers. Pharmaceutical liniments, pomades, medicinal soaps (AG).		
Fabaceae	*Pterocarpus officinalis* Jacq.	Sangre de drago (Guatemala, Nicaragua), sangregado (Nicaragua), *kaway* or swamp *kaway*" (Belize), sangre or *cowee* (Honduras)	As in other species, a blood red resin exudes. Formerly used in medicine as "dragon's blood," large quantities sent to Spain from Cartagena, Columbia.	S (1946 (24, V):340-342), 1982:508)	?

Family	Genus and species	Common name	Uses and notes	Source	*
			"Insipid...inodorous." (S)		
Hamamelidaceae	*Liquidambar styraciflua* L.	*So te* (Berlin), Liquidambar (genl.), *Ocotzoquauitl*, *Xochiocotzoquauitl* *Ocotzoquauitl* (AD), árbol de liquidambar indio (H), *nabá* (Chiapas), maripenda (Tarascan), *yaga bito*, *nite-biito* (Zapotec), *ocozotl*, *copalme* (R) (Veracruz), *Ocosote* (Oaxaca), estoraque[21] (Oaxaca, Guatemala (Cobán) liquidambar, *ocop*, *occob*, *ocóm* (K'ek'chi'), *tzoté* (Huehuetenango, Guatemala), quiramba (Tactic, Alta Verapaz, Guatemala), trementina (M), *ococoll* [sic], storacke (Monardes), *kirambaro* (AL), árbol de murciélago (M. de M.),	"It is rough, thick, round. It has a liquid, it exudes a liquid. Its bark is chopped; from there the resin, the liquidambar, comes out (AD);" Reddish, pleasant fragrance, similar to estoraque, mixed with tobacco it strengthens the head, stomach, and heart, produces sleep, and relieves head pain, skin rashes, flatulence, dissolves tumors, aids digestion, relieves uterine infections; boiling stems in water produces an inferior medicine (H). Tribute item (P & P). Bark syrup for	Berlin (566); AD, Book XI, p. 112; H 1943:359-60; P & P; R 151) S (1946 (24, IV):427-429, 1982:317); P & P (1992); X (1967:244-245); MO (I:11-13, 20-22); M (1959b:371-3, 1959a:449); Badi. (1996:28-32,142, F. 17 v.); AL (1984:690); M. de M.:cap. 20); Will. (1981:144)	A

[21] Ximénez' description of Guatemalan estoraque is confusing and appears to state that the medicinal properties of this resin are not well recognized, as they are in "el oriente" (Far East, eastern Guatemala?).

Family	Genus and species	Common name	Uses and notes	Source	*
		diquidambo, lesquín, styrax, storax, balsam, sweet gum (Will.)	diarrhea and dysentary. Medicine. In U.S., used as breath freshener, remedy for diarrhea and dysentary, especially in children, veterinary, hardened gum used to clean and "preserve" teeth[22] (S); so fragrant that it can be irritating, exported to Spain for "differentes confecciones." Headaches, stomachic, provokes menses, glove dressing in Spain, hot in the end of the second degree and moist in the first (Monardes). Veterinary, unguents and plasters, stimulant, sudorific,		

[22] Standley and Steyermark (1946) states that large amounts of liquidambar resin were shipped to Spain from Central America and Mexico.

Family	Genus and species	Common name	Uses and notes	Source	*
			stomachic, diuretic, gonorrhea (M). Toothache (Badi.). Construction only (AL).		
Moraceae (latex)	*Castilla elastica* Cervantes	*Olquauitl*, *olli*, *olcuahuitl* (Nahuatl), *tarantaqua* (Michoacán), *k'ik* (Kakchikel and K'iché), *quik* (Pokomam), "*yaxha,*" "kiikche'(Yucatan), *peem* (AL)	"It is thick, like a spindle-whorl, like the silk cotton tree. It has a liquid. Its bark is chopped; there comes out; there exudes the rubber. It is a medicine, a remedy for all ailment —a remedy for eye ailments, for festering. It is potable. With chocolate, it relieves our stomach, our intestines. It restores our internal organs; it cures where there is infection. The rubber exudes, it thickens; it is fibrous, nerve-like, tough; it jumps. It is soft, spongy, flesh-like"	AD, Book XI, p. 112; Standley (1946 (24, IV):18-20, 1982:214-216); Hernández Thesaurus 50, 1651, as cited in Standley (1982:214-216); F (1985:80); Badi. (44-45, 144, F. 31 r.); AL 1984:584)	A

Family	Genus and species	Common name	Uses and notes	Source	*
			(AD). Only Central American commercial source of rubber in Mexico and Central America (S). Added to food it fattens, appeases thirst, calms the bowels, dissipates ulcer (H in S). Headache without fever, sprains or broken bones, rheumatism, sore back, severe injury, toothache, chest pain, ritual (AL).		
Moraceae (latex)	*Ficus* spp.	*Amacoztic, texcalamatl* (Nahuatl), *hopoy, ts'uh, hopoy ts'uh, tsakam ts'uh*[23] (AL)	Complex issue, because numerous species may have been the source of milky latex used medicinally by Nahua and Maya, as well as of paper sources (S). Dog bite, headache, fuel,	See S (1982:205-213); AL (653-654)	A

[23] Alcorn cites four *Ficus* species whose latex is used by Huastec Maya: *F.* aff. *glaucescens* (Liebm.) Miq., *F.* aff. *jacquinifolia* A. Rich, *F. obtusifolia* H. B. K., *F. padifolia* H. B. K.

Family	Genus and species	Common name	Uses and notes	Source	*
			vulnerary, hemorrhage, sprain, broken bones, toothache, speeds healing of wounds, respiratory, sores, GI (dysentary) (AL).		
Pinaceae	*Abies religiosa* (H.B.K.) Schlect and Cham.;	*Oyametl*, *acxoyatl*, abieto, pino oyamel, *xalócotl*, cipreso (Guatemala) (S), aceite de palo" or "aceite de beto, pinobete, abeto	Source of trementina de abete; tapped in winter for oleoresin. Used in medicine for balsamic properties. Branches often used in churches (S). Remedy against molestation by whirlwind or gales, restoration of public officials (Badi.).	AD, Book XI, p. 106; S (1982:59); M 1959b:169); Badi. (1996: 74-75, 136, 144, F. 52 r., 56-57, F. 39 v.)	A M
Pinaceae	*Pinus spp.*	Pino, *ocote*, *ocotl*, *teocote* (Nahautl, oco: pine, -tl: primary suffix), copal negro, *ocotzotl*, trementina de pino, *oxitl* (oil of pine)	Ritual (Huitzilopochtli; altar adornment); resin torch; resin mixed with tobacco unguent and smoked (D, AD); mixed with powdered *Crotalaria* sp. or *Swartia nitida* for abcesses (Sahagún,	Durán 1971:n10, p. 81, AD, Book XI:242;Standley (1982:55); H (354-5); AD, Book XI:242; BL (415, 441, 443); X (1967:237-	A M

Family	Genus and species	Common name	Uses and notes	Source	*
			op. cit., p. 362) (AD); groin swellings and jigger fleas; poultice for nerves or bones (in absence of fever) (D); as "black" or bitumen. [24]Tie beam, beds, tortilla press, crosses, etc. Snake bite, soul loss, spider bite, stomachache, used against "wind" (chills and fever, swelling). Considered wild in Colonial times (BL). Copal negro incense logs used in rituals (pers. observ.) resin mixed with ocelet flesh and burned for vicious	238); Du (376-377); Badi. (1996:228, 237, 56-57, F. 39 v., 145)	

[24] The entire quote is very interesting: "It is the smoke of pine pitchwood, the lampblack of pine pitchwood. It is a medium for blackening, for dyeing, for tracing lines, for blending with black.." It is powdery, finely powdered, pulverized. It is that which admits water, which blots, which stains. I dye something black. I blacken something. I blend something with black. I make black lines on something. I blacken something. I darken something " (AD, Book XI:242).

Family	Genus and species	Common name	Uses and notes	Source	*
			behavior (D); leprosy (H);		
Pinaceae	*Pinus ayacahuite* Ehrenberg	*K'isis tah* (Berlin), *Ayauhquaitl*, *ocote* blanco, pino real (Oaxaca), *tzajal k'uk toj* ("red pine," Tzotzil, BL), pinabete, *acalocote*, Mexican white pine (Perry), pino (Guatemala)	Tree branches or tips used to decorate Tzotzil creche (BL). Lightning wound (Badi.). Torches.	Berlin (297); AD, Book XI, p. 106; Santamaría, as cited in AD; BL:182-184; Perry (52-54); X (1967:237-238); Badi. (1996:70-73, 135, F. 50 r.)	A
Pinaceae	*Pinus hartwegii* Lindl.	*Ocotl*, *ocote*	General uses shared by other pines.	H (355)	A
Pinaceae	*Pinus michoacana*	*Ajan toj* (Tzotzil, BL)	Unidentified ceremonial uses, used as ingredient in "flower water" for adults and newborns.	BL (183, 375, 437)	M
Pinaceae	*Pinus montezumae* Lamb.	*Bac'il tah* (Berlin), Montezuma pine, *ocote* blanco, *yutnusatnu* (Mixtec), *ocotl*, *ocote*, pino real, *ocote* macho, *ocote* hembro (S)	Resin used for healing open wounds (S).	Berlin (297); Perry (110-120); S (9182:56)	A?
Pinaceae	*Pinus montezumae* var. *rudis*	*Batz'i toj* (Tzotzil, BL)	Unidentified uses.	BL (375)	M
Pinaceae	*Pinus oaxacana*	*Bac'il tah* (Berlin), *ik'al toj* ("black pine," BL)	Unidentified ceremonial uses.	Berlin (297); BL (183, 375,	M

Family	Genus and species	Common name	Uses and notes	Source	*
			Ingredient in "flower water" for adults and newborns.	437)	
Pinaceae	*Pinus oocarpa* Schiede	*Bac'il tah* (Berlin), *tzajal toj*, red pine (Tzotzil) Chiapas, (BL), *ocote* (Río Balsas) (SN & S), *ocote* chino, pino prieto, pino colorado (Perry)	Resin torches, "hot" tea of thirteen slivers, with thirteen slivers of *tzajal tulan* (*Quercus rugosa*) brewed for treatment of loose tooth, mixed with *xchenek' tzajal om* (*Rhynchosia pyramidalis*, Fabaceae) antidote for "cold" of black widow spider bite (BL); resin used as a "poultice" for bone fractures, and it is said to clean and help the bone avoid "gripping cold" (SN & S).	Berlin (297); BL: 182-184, 188, 124; SN & S (1995:104); Perry (172-179); S (1982:58)	M
Pinaceae	*Pinus pseudostrobus* ***Need auth.	*Cik tah* (Berlin), *chak toj* (BL)	Unidentified uses.	Berlin (297)BL (1993:375)	M
Pinaceae	*Pinus teocote* Cham. and Schlect.	*Tzajal toj*, red pine (Tzotzil, BL), *ocote*, *jalocote*, Aztec pine, pino	Resinous wood as candles, fire starter (Berlin). Resin	Berlin (297-298); BL: 182-184, 188, 124;	M

Family	Genus and species	Common name	Uses and notes	Source	*
		real, pino chino (Perry), *xalócotl* (S)[25], *pithomlaab* (AL)	torches ("fat pine" slivers), "hot" tea of thirteen slivers, with thirteen slivers of *tzajal tulan* (*Quercus rugosa*) brewed for treatment of loose tooth, mixed with *xchenek' tzajal om* (*Rhynchosia pyramidalis*, Fabaceae) antidote for "cold" of black widow spider bite (BL); source of turpentine (trementina de *ocote*, *ocotzol*) used as balsamic stimulant, tar used for torches and manufacturing soap (S). General illness, GI (gas), dizziness, stomachic (AL).	Perry (191); S (1982:56); AL (1984:748-749)	
Sapotaceae	*Manilkara sapote*	Chicle, chicle zapote,	Primary modern	S (1982:1119-	A

[25] Standley states the following: The Aztec name, "*xal-ocotl*," signifies "sand pine," the name "teocote," "pine of the gods." Robelo states that this name was given because of the fact that only the nobles were permitted to use the resin as incense (as stated in Standley (1982:1644).

Family	Genus and species	Common name	Uses and notes	Source	*
	(Jacq) Gilly=*Achras sapote* L.	*tzicozapotl*, (Nahuatl), palo María (Yucatán, Chiapas), *ya* (Yucatán, Maya), perućtano, zapote de abejas (Yucatán), *guenda-xiña* (Oaxaca, Zapotec), níspero (Central America), *muyozapot* (EL Salvador), mamey (S), *ciktć* (M), *tsah it'ath* (AL)	product is chicle. Aztecs chewed it, and figures molded from it (S). GI (dysentary) (AL)[26]	1120); M (1959:211-213); AL (1984:699)	M
Styracaceae	*Styrax argenteus* Presl	Capulín, hoja de jabón, (Oaxaca), *chilacuate* (Michoacán, Guerrero), resino, resina (Nicaragua, Costa Rica), estoraque (El Salvador, Costa Rica, Guatemala), *ja'as te,' tztiz te*, 'mamey sapote tree, (Tzotzil, BL); *tepeaguacate*, naranjo, duraznillo, álamo (Guatemala, Will.)	In Costa Rica and probably elsewhere "gum" is burned as incense in churches. Bark said to be employed in El Salvador for stupefying fish; used for wattle, as ridge pole, roof, or roof rod, and firewood among Tzotzils. Fruit are occassionally eaten. Incense (Will.)	S (1946 (24, VIII, 1, 2):259-260, 1982:1130); BL (1993:149, 175, 414); Will. 1981)	M
Zygophylla-	*Guaiacum coulteri*	Palo Santo, guayacán,	Resin used as	S (1982:524)	M

[26] The Huastec Maya recognize three local varieties, but only the red barked group is used medicinally (Alcorn 1984:699).

Family	Genus and species	Common name	Uses and notes	Source	*
ceae	A. Gray	*yaga-na* (Oaxaca, Zapotec), *yutnu-tandaa* (Oaxaca, Mixtec) *matlaquahuilt* (Nahuatl)	stimulant, alterative, diaphoretic, and in larges doses purgative.		
	Guaiacum sanctum L.	*Zon* or *zoon*, Palo santo (Yucatán), guayacán, guiacan, holy wood	Resin used as stimulant, alterative, diaphoretic, and in larges doses purgative. Introduced into Europe about 1508 for medicinal properties (lignum-vitae). Offical medicine in U.S. Pharmocopeia with stimulant and diaphoretic properties (S). Hot, dry in second degree. Remedy for syphilis (Monardes).	S (1946 (24, V):393-396, 1982:523); MO (I 29-33)	M

Appendix 2. Data on resin sample purchases made in Guatemala and samples analyzed by FTIR

Notes:

•In column G, *Resin Uses*, I=incense, M=medicine, IL=illumination source, A=aromatic wood chips, NG=not given.

•An asterisk next to sample number indicates sample was analyzed using FTIR; sample number corresponds to FTIR sample number

•An aldea is equivalent to a hamlet or settlement. The definition of a league as used by the K'iché has not yet been determined exactly, but the approximate distance is fifteen miles.

•Departments are geographic and political entities roughly equivalent to states as in the United States

A	*C*	*D*	*E*	*F*	*G*	*H*	*I*
Sample number /Tentative FTIR identification	**Country**	**Town**	**Depart.**	**Name**	**Use**	**Cost (Q) / Quantity**	**Accompanying notes: physical characteristics of samples, vendor statements, geographical notes, etc.**
* KT 1 *Liquidambar styraciflua?*	Guate	Toto.	Toto.	Estoraque	I	Q.30	Mass of small twigs completely covered with shiny, hard layer of resin. Second piece of sample is a branch of 2.5 cm. Very light-weight and sweetly fragrant. Bark doesn't seem to

							resemble *Pinus* but may be too immature to display characteristic bark. However, branches display potential for whorled arrangement. Whitish sap present. Totonicopán is 14.5 km from Cuadros Caminos on PanAm Hwy. Alt. 2500m. Capital of dept. Approx. 52,000, mostly Quiché.
• KT 2 Pinaceae? Strong spectral resemblance to KT 20	Guate	Toto.	Toto.	Morambia	M	.30/oz.	Two largish bits of bark about 3-5 cm. width with lumps of resin on outside. Bark scaly and whitish as in some pine species. Bark completely absent on some pieces. Vendor: "Morambia tosterina, se cose y se tomar con azucar." For throat; boil five minutes. Strain, add sugar. All samples purchased in dry goods area of interior market, first floor.
• KT 3 Unknown	Guate	Toto.	Toto.	NG	I, M	NA	Drink hot, 3-4 times/day. Vendor: copal is not from Guatemala. Granular, sugar-like globules. Slight reddish color. No signs of bark or organic matter.
• KT 4 *Bursera copallifera*	Guate	Toto.	Toto.	Incienso criollo	I	.40/oz.	"The best." 2nd informant says name might imply that source might grow in region. Yellowish, waxy, rounded globules. A vendor in Chichicastenango later said that this incense "has the best odors."
• KT 5 *Pinus*	Guate	Toto.	Toto.	Copal amarillo	I	.50/oz.	Deep yellow, translucent. Very hard. Either flow or cooked. Various sizes:

caribbaea							1-5 to 7x4 cm.
KT 6 *Pinus* spp.	Guate	Toto.	Toto.	*Ocote*	IL	.25/bundle	Resins in wood shards used for cough. Boil 25 min. Strain. Wood dried for bone setting in Comalapa (Chimaltenango).
KT 7a *Pinus* spp., *Quercus* spp.	Guate	Toto.	Toto.	Copal negro	I	2.00/log	Large log. Wrapped with petioles of banana leaves and tied with maguey fibers. Bought from same vendor as 7b.
KT 7b *Pinus* spp., *Quercus* spp	Guate	Toto.	Toto.	Copal negro	I	.60/log	Small log. Purchased with 7a.
* KT 8 *Pinus oocarpa*	Guate	Chich i.	Chich.	Incienso negro	I	NA	Purchased in market directly across from main church in square. Told by 2nd informant that pine resin burns with black smoke, this sample burns w/ white. Vendor 70-80 years old, female. Little or no Spanish. Little girl spoke Spanish but no information. One guide book says "copal candles" sold in Chichi. I suspect this is a mistake. One vendor asked if he ever sold them and he said no, just incienso negro.
* KT 9 Unknown.	Guate	Chich i.	Chich.	Copal	I	1.50/oz.	Similar in form to estoraque (KT 1) from Toto. Produces black smoke. 2nd informant thinks small woody twigs are encina (*Quercus* spp.) left under a wounded pine. Also believes resin not previously melted b/c material would be hard and shiny. Th/Su market. Alt. 2700m. 1,000

							Ladinos, 20,000 Maya
KT 10 *Pinus* spp., *Quercus* spp.?	Guate	Chichi.	Chich.	NG	I?	2.50/8 oz.	Mixture of encina and pine bark? Possibly used as smoldering medium for incense. Burns slowly and smokes heavily. Produced white smoke. 2nd informant thinks sample consists of only encina bark. "Good material for charcoal," i.e., to keep charcoal burning.
KT 11 *Pinus* spp., *Quercus* spp.?	Guate	Chichi.	Chich.	NG	?	NA	Same as above.
* KT 12a *Pinus oocarpa* or *Hymenaea courbaril*	Guate	Antigua	Sacat.	NG	I	3.00/chunk	Hard yellow chunk, molded into distinctive shape of baking pan corner. Cooked? Bought from old man in vegetable market. When asked about the source, he said, "It is rock." When told it is from tree, said, "Yes," and no more. Resembles KT 5.
KT 12b	Guate	Antigua	Sacat.	NG	?	NA	Sold with KT 12a
* KT 13 Burseraceae?	Guate.	Tecpan	Chim.	NG	I	1.00/oz.	Bought in market from dry goods and ceramics vendor. Looks similar to KT 4 from Toto. Tecpan is also known as Iximché by Kakchikels. PreHispanic capital of K. kingdom.
KT 14 *Pinus* spp.	Guate	Tecpan	Chim.	*Ocote*	IL, M?	.40/small bundle	Same vendor as KT 13. Used for lighting fires for food preparation.
KT 15 Unknown.	Guate	Chiqui.	Chiq.	Copal blanco	I	1.00/small log	Purchased in Chiquimula market, close to Guatemala-Honduras border, from same dealer as KT 17. No information

							about differences in resins. Appears to be a composite. Distinctive from all other copals (see illus.). Extremely light wood with whitish, confection-like coating.
* KT 16 *Pinus caribbaea* var. *hondurensis* or Burseraceae	Guate	Chiqui.	Chiq.	Copal negro	I	Gift.	Purchased elsewhere in Chiqui. market and received as gift. Wrapped in corn husk and tied with fiber. Resin clearly distinct from that of copal negro from Momostenango (see below).
KT 17 *Pinus oocarpa* or *Hymenaea courbaril*	Guate	Chiqui.	Chiq.	NG	I	5.00/large chunk	Bought from same dealer as KT 15. Similar to KT 5, 12a, 17.
KT 18 *Pinus* spp., *Quercus* spp.?	Guate	Momos.	Toto.	Copal negro	I	1.50/log	Large log purchased from copal maker in Canquixajá, aldea of Momos. Wrapped in petioles of banana, wrapped w/ maguey fibers? Momostenango is "The Place of Altars." Local priests and shamans intimately involved w/ political and social organization of community. Alt. 2300 m. Market W/Su.
KT 19 *Pinus* spp., *Quercus* spp.?	Guate	Momos.	Toto.	Copal negro	I	.40/2 balls	Bought in small tienda behind church in market. When asked if vendor sold anything else but small logs, he brought these balls. These were not

							found anywhere else in Momos. market, at least in sight. Balls are of a rough texture and appear to be coarser than KT 17. Bark bits very evident.
* KT 20 Pinaceae? Strong spectral resemblance to KT 2	Guate	Mom os.	Toto.	Copal	M	2.00/oz.	Purchased from female vendor near edge of food section in market. Similar to morambia bought in Toto (KT 2). Vendor stated that copal was from Canquixajá, an aldea twelve "leagues" away and a center of copal processing. Vendors bring copal to Momos, where it is sold to wholesale retailers. The author arrived in Canquixajá on foot, as the road was under repair. The aldea is not located on any map.
KT 21 *Pinus* spp. or *Hymenaea courbaril*	Guate.	San Franc is-co El Alto	Toto.	Copal	I	NA	Purchased from vendor in market. Similar to KT 5, 12,
KT 22 *Pinus* spp.	Guate.	Nebaj	Quich.	NG	A	NA	Purchased from vendor in Nebaj. Not a large market day, only dry goods vendors available. No copal for sale. Wood chips are aromaric and used as a substitute for copal.
* KT 23 *Protium copal*	Guate	Lanq uín	A. V.	Copal *pom, pom*	I, M	15.00/lb.	Resin collected from *Protium copal* trees in area. See Chapter III.
* KT 24 *Bursera*	U. S. A.	Austi n	Texas	Mexican frank-	I	NA	Purchased by Beryl B. Simpson in retail shop.

copallifera				incense			
* KT 25 *Taxodium* spp.	U. S. A.	Medina	Texas	*Taxodium* spp.	NA	NA	Collected by author for resin collection. Resin exuding from tree root
* KT 26 *Picea* spp.	U. S. A.	North-west Harbor	Maine	*Picea* spp.	NA	NA	Collected by author for resin collection. Resin in blisters on trunk.

Appendix 3. Associated use categories of resin and latex-producing families and species

Family	Genus and species	Inc. 27	Med.	Rit.	Masti.	Latex source 28	Dom.	Glue or varnish	Vet.[29]	Other
Anacardiaceae	*Cyrtocarpa procera*		X	X	X					
	Kunthcarpa edulis (T.S. Brandeg.) Standl.	X	X	icons						
	Pistacia mexicana HBK.									
	Pseudosmodingium perniciosum (H.B.K.) Engl.	X								
	Schinus molle L.	X	X		X					
Apocynaceae	*Plumeria acutifolia* Poir.		X	X		X				flowers
	Plumeria rubra L.	X	X			?		X		
	Tabernaemontana amygdalifolia Jacq.				X					
Burseraceae	*Bursera aloexylon*									

27 Inc., incense; Medicine, general categories; Ritual, including church or altar decoration; Masticant: medicinal use of resin has been conflated into this category in order to include indication of palleability of particular resin material; Latex source indicates specific use of latex, not exudate *per se*; Domestic applications include use of materials as fencerows, house construction, etc.; Vet., veterinary; Per., perfume

28 Latex source indicates specific use of latex, not exudate *per se*.

29 Vet., veterinary

Family	Genus and species	Inc. [27]	Med.	Rit.	Masti.	Latex source [28]	Dom.	Glue or varnish	Vet.[29]	Other
Burscraceac	*Bursera aloexylon* Engl.									
	Bursera bipinnata Engl.	X	X	X	X		X			cultivated ?
	Bursera copallifera (DC.) Bullock (=*B. jorullensis* = *Elaphrium jorullensis*)	X	X							
	Bursera discolor Rzedowski		X							
	Bursera diversifolia Rose		X							
	Bursera excelsa Engl.	X	X	X			X			cultivated ?
	Bursera grandifolia (Schldl.) Engl.		X							
	Bursera graveolens (H. B. K.) Trinana & Planch		X							Cultivat-ed by Huastec Maya
	Bursera heteresthes Bullock		X						X	
	Bursera hintonii Bullock		X							
	Bursera microphylla (A.		X							tannins, dyes

Family	Genus and species	Inc. 27	Med.	Rit.	Masti.	Latex source 28	Dom.	Glue or varnish	Vet.[29]	Other
	Gray) Rose = *Elaphrium microphyllum* A. Gray									
	Bursera odorata (T. S. Brandeg.) Rose (=*Elaphrium multiugum, Elaphrium odoratum*)		X	X						
	Bursera sarukhanii Guevara et Rzedowski		X							
	Bursera schafferi (= *Elaphrium schafferi*)		X					X		
	Bursera simbaruba Sarg. (=*B. gummifera* Jacq.)	X	X		X					cultivated ?
	Bursera steyermarkii Standley		X							
	Bursera spp.		X							tannins dyes
	Bursera trijuga (Ramirez) Rose (=*Elaphrium trijugum*)		X							

Family	Genus and species	Inc. [27]	Med.	Rit.	Masti.	Latex source [28]	Dom.	Glue or varnish	Vet.[29]	Other
	Commiphora tecomaca (=*Bursera tecomaca* = *Elaphrium tecomaca* (DC.) Standl.)		X		X					
	Protium copal L.	X	X	X	X					
	Protium schipii	X								
	Protium spp.									no uses specified
Clusiaceae	*Calophyllum chiapense* Standl.		X							
Euphorbiaceae	*Croton alamosanus* Rose				X					
	Croton cortesianus H. B. K.		X							
	Croton draco Schlecht.								X	
	Croton morifolius Willd.		X							
	Croton stipulaceus H. B. K.									unknown
	Croton xalapensis H. B. K.				X					
	Euphorbia		X							

Family	Genus and species	Inc. 27	Med.	Rit.	Masti.	Latex source 28	Dom.	Glue or varnish	Vet.29	Other
	calyculata H. B. K.									
	Euphorbia cotinifolia L.		?							violent emetic-cathartic properties poisonous
	Euphorbia pulcherrima Willd.									depilatory
Fabaceae	*Hymenaea courbaril* L.	X	X					X		alcoholic beverage?
	Myroxylon balsamum var. pereirae (Royle) Harms		X							tribute item, perfume
	Pterocarpus officinalis Jacq.		X							export to Spain
Hamameli-daceae	*Liquidambar styraciflua* L.		X						X	tribute item, later exported to Spain
Moraceae	*Castilla elastica* Cervantes		X			X				source of rubber for ball game? commerc-ial source of rubber

Family	Genus and species	Inc. [27]	Med.	Rit.	Masti.	Latex source [28]	Dom.	Glue or varnish	Vet.[29]	Other
	Ficus spp.					X				paper source
Pinaceae	*Abies religiosa* (H.B.K.) Schlect and Cham.;		X	X						source of trement-ina de abeto
	Pinus ayacahuite Ehrenberg			X						
	Pinus hartwegii Lindl.									general uses shared by other pines
	Pinus lumholtzii Robins and Fern.	X								
	Pinus michoacana			X						
	Pinus montezumae Lamb.	X								
	Pinus montezumae var. *rudis*									uses not specified
	Pinus oaxacana			X						
	Pinus oocarpa Schiede		X		X					torches, turpent-ine
	Pinus teocote Cham. and Schlect.		X		X					torches, turpent-ine, soap

Family	Genus and species	Inc. 27	Med.	Rit.	Masti.	Latex source 28	Dom.	Glue or varnish	Vet.[29]	Other
	Pinus spp.	X	X	X			X			blacking, bitumen, torches, smoked
Sapotaceae	*Achras sapote* L. (=*Manilkara sapote* (Jacq.) Gilly				X	X				Mexica modeled figures from latex
Styracaceae	*Styrax argenteus* Presl	X					X			stupefy-ing fish
Taxodiaceae	*Taxodium mucronatum* L.		X							
Zygophyll-aceae	*Guaicum coulteri* A. Gray		X							carving?
	Guaicum sanctum L.		X							carving?

Appendix 4. Medicinal uses of resins in the Maya cultural region

Key:

Broken bones, *bb*
Carminative, *car*
Catarrh, *catt*
cough, *cou*
Dental problems, *dent*
Diarrhea/dysentary, *d d*
Dermatitis, *derm*
Emmenagogue, *emm*
Eye-related problems, *eye*
Febrifuge, *feb*
Flower water, *flow*
Gastro-intestinal, *g-i*
Genito-urinary, *g-u*
Headache, *head*
Medicinal tea, *tea*
Neuralgia, *neur*
Purgative, *purg*
Respiratory, *resp*
Scorpion or spider bites, *spid*
Snake anti-venom, *anti*
Stomachic, *stom*
Stimulant, *stim*
Styptic, *styp*
Swellings, inflammations, *infl*
Venereal disease, *ven*
Vermifuge, *verm*
Veterinary, *vet*
Vulnerary, *vuln*
No uses specified, *none*
Native characterization, when available,
temp
Modern uses only, *mod*

Family	Genus and species	Medicinal uses
Anacardiaceae	*Cyrtocarpa procera* Kunth	*cou, dent, d'd, stom, vuln*
	Cyrtocarpa edulis (T.S. Brandeg.) Standl.	*none*
	Pistacia mexicana HBK.	*none*
	Pseudosmodingium perniciosum (H.B.K.) Engl.	*purg, spid, poisonous*
	Schinus molle L.	*dent, eye, g-u, purg, ven, vuln*

Family	Genus and species	Medicinal uses
Apocynaceae	*Plumeria acutifolia* Poir.	*ven, vuln*
	Plumeria rubra L.	*cou, derm, corollas for cough, latex for ringworm, burns*
	Tabernaemontana amygdalifolia Jacq.	*dent, boils, dogbite*
Burseraceae	*Bursera aloexylon* Engl.	*neu, purg*
	Bursera bipinnata Engl.	*dent, derm, emm, flow, tea, infl, hot, rheumatism*
	Bursera copallifera (DC.) Bullock (=*B. jorullensis* = *Elaphrium jorullensis*)	*g-u, medicinal unguents, oral or bath for dolor del aire*
	Bursera discolor Rzedowski	*bb, feb, anti, vuln*
	Bursera diversifolia Rose	*ill defined morbid states, considered hierba del dolor, oral or bath for dolor del aire*
	Bursera excelsa Engl.	*flow, infl*
	Bursera grandifolia (Schldl.) Engl.	*vuln*
	Bursera graveolens (H. B. K.) Trinana & Planch	*head, systemic disease medicine*
	Bursera heteresthes Bullock	*bb, vet, vuln, hierba del dolor to relieve dolor del aire, unripe fruits for cough*
	Bursera hintonii Bullock	*vuln, unripe fruits for cough, external lesions*
	Bursera microphylla (A. Gray) Rose = *Elaphrium microphyllum* A. Gray	*d/d, ven, slightly astringent*
	Bursera odorata (T. S. Brandeg.) Rose (=*Elaphrium multiugum, Elaphrium odoratum*)	*d/d, purg, ven, dropsy, sudorific, diuretic*
	Bursera sarukhanii Guevara et Rzedowski	*g-u, resp, spid, pneumonia, dolor del aire, juvenile urinary incontinence*

Family	Genus and species	Medicinal uses
	Bursera simbaruba Sarg. (=*B. gummifera* Jacq.)	*dent, d/d, derm, feb, g-u, head, purg, resp, anti, verm, vuln, infusion is cold, antiparasitic, enema, poultice to prevent spread of gangrene, infections, nosebleeds, burns, measles*
	Bursera steyermarkii Standley	*feb, g-u, infl, bark and wood chip teas for heartburn and heart pain, chills; leaves for steam cures, flatulence*
	Commiphora tecomaca (=*Bursera tecomaca* = *Elaphrium tecomaca* (DC.) Standl.)	*infl, vuln*
	Bursera trijuga (Ramirez) Rose (=*Elaphrium trijugum)*	*d/d, feb*
	Bursera spp.	*catt, emm, stom, ven, smoke strengthens heart, uterus, keeps cold away from fevers, warms cold parts of body, restores fallen wombs and resulting depression. When mixed with dung, said to cure delirium without fever*
	Protium copal L.	*dent, emm, g-u, resp, stom, styp, verm, vuln, antiparasitic, rheumatism, GI pain or problems, children's stomach problems, earache*
	Protium schipii	*none*
Fabaceae	*Hymenaea courbaril* L.	*carm, catt, purg, resp, ven, verm, rheumatism, arterial sedative, sores, quinine substitute*
	Myroxylon balsamum var. *pereirae* (Royle)	*catt, d/d derm, feb, g-u, head, resp, stom, styp, infl, ven,*

Family	Genus and species	Medicinal uses
	Harms	*vuln, hot, scabies, gonorrhea, diuretic, prostate and liver conditions, oil for wounds and ulcer, pharmaceutical liniments, medicinal soaps*
	Pterocarpus officinalis Jacq.	*none, formerly used aas dragon's blood*
Hamamelidaceae	*Liquidambar styraciflua* L.	*carm, dent, d/d, derm, feb, stom, stim, ven, vet, medicinal unguents and plasters, sudorific, diuretic*
Pinaceae	*Abies religiosa* (H.B.K.) Schlect and Cham.;	*none, "used in medicine for balsamic properties"*
	Pinus ayacahuite Ehrenberg	*none*
	Pinus hartwegii Lindl.	*none*
	Pinus lumholtzii Robins and Fern.	*none*
	Pinus michoacana	*flow*
	Pinus montezumae Lamb.	*vuln*
	Pinus montezumae var. *rudis*	*none*
	Pinus oaxacana	*flow*
	Pinus oocarpa Schiede	*bb, dent, tea, anti, hot?*
	Pinus teocote Cham. and Schlect.	*dent, g-i, tea, anti, stom, stim, balsamic stimulant, flatulence, dizziness, general illness*
	Pinus spp.	*d/d, feb, neur, spid, anti, stom, infl, soul loss*
Styracaceae	*Styrax argenteus* Presl	*none*
Zygophyllaceae	*Guaicum coulteri* A. Gray	*purg, stimulant, alterative, sudorific*
	Guaicum sanctum L.	*purg, stim, ven, alterative, diaphoretic, sudorific*

Appendix 5. Medical definitions of medical terms associated with plant resins used by Southern Mexican and Central American Maya

Medical terms and conditions	Definition[30]
alterative (n)	medicine that gradually restores normal body functions, or stimulates changes of a defensive nature in metabolism and tissue function in the presence of chronic and acute disease
anthelmintic (n)	destroying or ejecting intestinal worms
antiodontalgic	against toothache
carminative (adj)	expelling gas from stomach and intestines
catarrh (n)	inflammation of a mucus membrane, particularly throat and nose, and increased secretion of mucus
cathartic (n)	medicine that stimulates evacuation of the bowels; a purgative or laxative
decoction (n)	an extract produced by boiling
depurative (adj.)	Purifying, tending to cleanse
dermatitis (n)	inflammation of the skin
diaphoretic (adj)	increasing perspiration
diuretic (adj)	increasing urinary charge
emetic (n)	medicine or substance that causes vomiting
emmenagogue (n)	anything used to assist and promote menstrual discharges
emulsion (n)	suspension of a very fine oily or resinous liquid in another liquid
enema (n)	a liquid injected into the rectum either as a purgative or a medicine
infusion (n)	to steep or soak, extract certain properties
neuralgia (n)	a pain in the nerve or nerves; the condition characterized by such pain
pectoral (n)	medicine used on breast or chest

[30] Definitions derived from Moore (1989) and Webster's *New Universal Unabridged Dictionary* (1983). 2nd. ed. Simon and Schuster.

plaster (n)	a pasty preparation spread on a cloth and applied to the body, used medicinally as a curative or irritant
poultice (n)	a hot soft, hot, moist mass applied to sore and inflamed parts of the body
purgative (adj)	purging. causing bowel movements
rubefacient (n)	a substance that, when applied topically, dilates the blood vessels under the skin and brings heat to the area. If blistering occurs, it is termed a vesicant
stomachic (n)	digestive tonic
styptic (adj)	tending to halt bleeding by contracting the tissues or blood vessels; astringent
sudorific (adj)	increasing perspiration
unguent (n)	salve or ointment
vulnerary (adj)	used for healing wounds

Literature cited

Adams, R. 1989. *Identification of Essential Oils by Ion Trap Mass Spectrometry*. San Diego, Academic Press.

Adamson, A. D. 1971. *Oleoresins. Production and Markets with Particular Reference to the United Kingdom*. G 56. London, Tropical Products Institute.

Aguilar Girón, J. I. 1966. *Relación de Unos Aspectos de la Flor Util de Guatemala*. Published by the author, Guatemala.

Aguilar, J. M. 1982. *Catálogo de Arboles de Guatemala*. Guatemala City, Editorial Universitaria.

Alcorn, J. B. 1984. *Huastec Mayan Ethnobotany*. Austin, University of Texas Press.

American Chemical Society. 1955. *System of nomenclature for terpene hydrocarbons:acyclics, monocyclics, bicyclics; A Report of the Nomenclature Committee of the Division of Organic Chemistry*, American Chemical Society.

Arvigo, R., Epstein, Nadine, Yaquinto, Marilyn. 1994. *Sastun: My Apprenticeship with a Maya Healer.* San Francisco, Harper.

Banthorpe, D. and B. Charlwood. 1980. The terpenoids *in Encyclopedia of Plant Physiology*. E. Bell and B. Charlwood [eds.] Berlin, Springer-Verlag.

Barrera Marin, A., A. Barrera Vasquez and R. M. Lopez Franco. 1976. *Nomenclatura etnobotanica Maya: una interpretación taxonómica*. Mexico, Instituto Nacional de Antropologia e Historia.

Barrera-Vásquez, A. 1980. *Diccionario Maya Cordemex, Maya-Español, Español-Maya*. Mérida, Yucatán, Ediciones Cordemex.

Bartlett, H. H. 1935b. Method of procedure for field work in tropical American phytogeography, based upon a botanical reconnaissance in parts of British Honduras and the Peten. *Carnegie Institute Publication 461*. 1-25.

Becerra, J. X. 1997. Insects on plants: macroevolutionary chemical trends in host use. *Science* **276**: 253-256.

Becerra, J. X. and D. L. Venable. 1999a. Nuclear ribosomal DNA phylogeny and its implications for evolutionary trends in Mexican *Bursera*. *American Journal of Botany* 86:1047-1057.

Becerra, J. X. and D. L. Venable. 1999b. Macroevolution of insect-plant associations: The relevance of host biogeography to host affiliation. *Proceedings of the National Academy of Sciences*. 12626-12631.
Beck, C. W., E. Wilbur and S. Meret. 1964. Infra-red spectra and the origin of amber. *Nature* **201**: 256-257.
Berlin, B., D. E. Breedlove and P. H. Raven. 1974. *Principles of Tzetzal Plant Classification*. New York and London, Academic Press.
Bianchi, E., M. E. Caldwell and J. R. Cole. 1968. Antitumor agents from *Bursera microphylla* (Burseraceae) I. Isolation and characterization of deoxypodophyllotoxin. *Journal of Pharmaceutical Chemistry* **57**: 696-697).
Bianchi, E., K. Sheth and J. B. Cole. 1969. Antitumor agents from *Bursera fagaroides* (Burseraceae) (B-peltatin-a-methylether and 5'-desmethoxy-B-peltatin-a-methylether). *Tetrahedron Letters* **32**: 2759-2762.
Böttcher, H. 1964. *Wonder Drugs: A History of Antibiotics*. Philadelphia & New York, J. B. Lippincott.
Breedlove, D. E. and R. M. Laughlin. 1993. The Flowering of Man: A Tzotzil Botany of Zinacantán. *Smithsonian Contributions to Anthropology*(35).
Bunzel, R. 1967. *Chichicastenango; a Guatemalan village*. Seattle, London, University of Washington Press.
Cáceres, A. 1996. *Plantas de Uso Medicinal en Guatemala*. Guatemala, Editorial Universitaria.
Cáceres, A. and B. Samayoa. 1989. *Tamizaje de la Actividad Antibacteriana de Plantas Usadas en Guatemala*. Guatemala, Universidad de San Carlos de Guatemala.
Carlsen, R. S. 1997. *The War for the Heart & Soul of a Highland Maya Town*. Austin, University of Texas Press.
Carlson, R. and F. Eachus. 1977. The Kekchi Spirit World. *Cognitive Studies of Southern Mesoamerica*. H. L. Neuenswander. Dallas, Summer Insitute of Linguistics Museum of Anthropology: 36-65.
Carter, W. E. 1969. *New Lands and Old Traditions: Kekchi Cultivators in the Guatemala Lowlands*. Gainesville, University of Florida Press.
Castorena, J. L., L. A. Garza-Valdes and B. Stross. 1993. *Archaeological Sample Identified as Copal (Bursera bipinnata) by Capillary Gas Chromatography/Mass Spectometry*. Society of American Archaeologists in St. Louis, Missouri, September 15, 1993.

CEMAT (Centro Mesoamericano de Estudios sobre Tecnología Apropiada Laboratorio, y Droguería de Productos Fitifarmacéuticos FARMAYA). 1992. *Fichas Populares sobre Plantas Medicinales*. Guatemala City, The authors.

Charlwood, B. V. and D. V. Banthorpe, eds. 1991. *Terpenoids*. London, Academic Press.

Chattaway, M. M. 1951. The development of horizontal canals in rays. *Australian Journal of Scientific Research* **4**: 1-11.

Central Intelligence Committee. 1972. *Map: Guatemala*. N.p., CIA.

Cobo, B. 1890. *Historia del Nuevo Mundo*. Seville, Imprenta de E. Rasco.

Coe, M. and S. Coe. 1996. *The True History of Chocolate*. London, Thames and Hudson.

Coggins, C. C. and Shane III, Orrin C. 1984. *Cenote of Sacrifice: Maya Treasures from the Sacred Well at Chichén Itzá*. Austin, University of Texas Press.

Comerford, S. C. 1996. Medicinal plants of two Mayan healers from San Andrés, Petén, Guatemala. *Economic Botany* **50**(3):327-336.

Coppen, J. J. W. 1995. *Gums, Resins and Latexes of Plant Origin*. Rome, Food and Agriculture Organization of the United Nations.

Cronquist, A. 1981. *An Integrated System of Classification of Flowering Plants*. New York, Columbia University Press.

Cruz, Martín, de la. 1991 [1552]. *Libellus de Medicinalibus Indorum Herbis* [*Badianus Codex*]. Mexico,

Cruz Torres, Mario Enrique de la. 1967. *Las Leyendas, Mitos, Fabulas y su Influencia en la Vida Actual del Indigena Quekchi*. Guatemala, Tipo Nacional.

Daly, D. 1987. Studies in neotropical Burseraceae I. A Synopsis of the genus *Crepidospermum*. *Brittonia* **39**: 51-58.

Daly, D. 1989. Studies in neotropical Burseraceae. II. Generic limits in New World Protieae and Canarieae. *Brittonia* **41**: 17-27.

Daly, D. 1992. New taxa and combinations in *Protium* Burm. f. Studies in neotropical Burseraceae VI. *Brittonia* **44**: 280-299.

Dieterich, K. 1901. *Analysis of resins, balsams, and gum-resins; the chemistry and pharmacognosis. For the use of the scientific and technical research chemist.* London, Scott, Greenwood, & Co.

Dolara, P., Luceri, Cristina, Ghelardini, Carla, *et al.* 1996. Analgesic effects of myrrh. *Nature* **379**: 29.

Dominguez, X. A., Rzedowski, J., Gutierrez, M., Gomez, M. E. 1973. A phytochemical survey of 21 species of the genus *Bursera* natives of Mexico. *Revista Latino Americano Quimica* **4**: 108-111.
Duke, J. 1998. Phytochemical and Ethnobotanical Databases. http://www.ars-grin.gov/cgi-bin/duke/farmacy2.pl, http://probe.nalusda.gov:8000/related/aboutethnobotdb.html, Agricultural Research Services.
Duke, J. A. 1981. *Handbook of Legumes of World Economic Importance*. New York and London, Plenum Press.
Edmonson, M. S. 1982. *The Ancient Future of the Itza: The Book of the Chilam Balam of Tizimin*. Austin, University of Texas Press.
Edmonson, M. S. 1986. *Heaven Born Merida and Its Destiny: The Book of Chilam Balam of Chumayel*. Austin, University of Texas Press.
Esau, K. 1965. *Plant Anatomy*. New York and London, John Wiley & Sons.
Estrada Monroy, A. 1990. *Vida Esotérica Maya-Kekchi*. Guatemala, Ministerio de Cultura y Deportes.
Estrada-Monroy. 1979. *El Mundo K'ekchi de la Verapaz*. Cobán [Guatemala], Ministerio de la Defensa Nacional.
Evans, W. C. 1996. *Trease and Evans' Pharmacognosy*. London, W.B. Saunders Co.
Fahn, A. 1979. *Secretory Tissues in Plants*. London, Academic Press.
Fahn, A. and J. Benayoun. 1976. Ultrastructure of resin ducts in *Pinus halapensis*: development, possible sites of resin synthesis, and mode of its elimination from the protoplast. *Annals of Botany* **40**: 857-863.
Fahn, A. and E. Zamski. 1970. The influence of pressure, wind, wounding and growth substances on the rate of resin duct formation in *Pinus halapensis* wood. *Israel Journal of Botany* **19**: 429-446.
Farjon, A., J. A. Perez de la Rosa and B. T. Styles. 1997. *A Field Guide to the Pines of Mexico and Central America*. Richmond [Surrey, England], The Royal Botanic Gardens, Kew.
Farrah, A. Y. 1994. *The Milk of the Boswellia Forests: Frankincense Production Among the Pastoral Somali*. Uppsala, The author and Research Programme in Environmental Policy and Society.
Farriss, N. M. 1984. *Maya Society Under Colonial Rule: The Collective Enterprise of Survival*. Princeton, Princeton University Press.
Feldman, L. H. 1985. *A Tumpline Economy: Production and Distribution Systems in Sixteenth-Century Guatemala*. [Culver City, CA], Labyrinthos.

Feller, R. L. 1954. Dammar and mastic infrared analysis. *Science* **120**: 1069-1070.
Folan, W. J., L. A. Fletcher and E. R. Kintz. 1979. Fruit, fiber, bark, and resin: Social organization of a Maya urban center. *Science* **204**: 697-701.
Forestales, Instituto Nacional de Investigaciones. 1980. *Situación de la industria resinera en Mexico*, Secretaria de Agricultura y Recursos Hidraulicos, Subsecretaria Forestal y de la Fauna, Instituto Nacional de Investigaciones Forestales.
Freidel, D., L. Schele and J. Parker. 1993. *Maya Cosmos: Three Thousand Years on the Maya Path*. New York, William Morrow.
Gall, Francis. 1976-1983. *Diccionario Geográfica de Guatemala*. Guatemala, Instituto Geográfica Nacional.
García Palacio, Diego de. 1985. *Carta Dirijida al Rey de España, 1576*. Culver City [CA], Labyrinthos
Gershenzon, J. and R. Croteau. 1991. Terpenoids in *Herbivores: Their Interactions with Secondary Plant Metabolites. Vol.I: The Chemical Participants*. G. A. Rosenthal and M. R. Berenbaum. San Diego, Academic Press.
Gianno, R. 1990. *Semelai Culture and Resin Technology*. New Haven, The Connecticut Academy of Arts and Sciences.
Gomez-Vasquez, B. G. and E. M. Engleman. 1984. Bark anatomy of *Bursera longipes* and *B. copallifera*. *International Association of Wood Anatomists Bulletin* **5**: 335-340.
Gooch, A. and A. Garcia de Paredes, eds. 1978. *Cassell's Spanish-English English-Spanish Dictionary*. New York, McMillan.
Goodwin, T. W. and E. I. Mercer. 1972. *Introduction to Plant Biochemistry*. Oxford, Pergamon Press.
Gossen, G. H. 1974. *Chamulas in the World of the Sun: Time and Space in a Maya Oral Tradition*. Cambridge [MA], Harvard University Press.
Groom, N. 1981. *Frankincense and Myrrh: A Study of the Arabian Incense Trade*. New York, Longman.
Guatemala, Instituto Geográfica de. 1966. Mapa Preliminar de la República de Guatemala. Instituto Geográfica de Guatemala.
Hale, A. 1911. Balsam of Peru, a Central American contribution to the pharmacopaeia. *Bulletin of the Pan American Union*. 880-881.
Healey, K. 1991-1992. Traveller's Reference Map of Guatemala and El Salvador. Vancouver, International Travel Map Productions. 1:500,000.

Hegnauer, R. 1962-. *Chemotaxonomie der Pflanzen; eine Ubersicht uber die Verbreitung und die systematische Bedeutung der Pflanzenstoffe*. Boston, Birkhauser Verlag.

Hernández, F. 1943. *Historia de las Plantas de Nueva España*, Vol. II. Mexico, Imprenta Universitaria.

Holland, W. R. 1989. *Medicina Maya en los Altos de Chiapas*. Mexico, Consejo Nacional para la Cultura y las Artes.

Howes, F. N. 1949. *Vegetable Gums and Resins*. Waltham [MA], Chronica Botanica.

Islebe, G. 1994. Will Guatemala's *Juniperus-Pinus* forests survive? *Environmental Conservation*. 167-168

Kar, A. and M. K. Menon. 1969. Analgesic effect of the gum resin of *Bursera serrata*. *Life Sciences* **8**: 1023-1028.

Khalid, S. A. 1983. Chemistry of the Burseraceae in *Chemistry and Chemical Taxonomy of the Rutales*. P. G. Waterman and M. F. Grundon, eds. New York, Academic Press.

King, A. 1974. *Coban and the Verapaz: History and Cultural Process in Northern Guatemala*. New Orleans, Middle American Research Institute, Tulane University.

Lambert, J. D. H. and J. T. Arnason. 1982. Ramón and Maya ruins: an ecological, not an economic, relation. *Science* **216**: 298-299.

Langenehim, J. H. 1969. Amber: A botanical inquiry. *Science* **163**: 1157-1169.

Langenheim, J. H. 1973. Leguminous resin-producing trees in Africa and South America *in Tropical Forest Ecosystems in Africa and South America: A Comparative View*. B. J. Meggers, E. S. Ayensu and W. D. Duckworth, eds. Washington, D. C., Smithsonian Press: 89-104.

Langenheim, J. H., Ed. 1981. *Terpenoids in the Leguminosae*. Advances in Legume Systematics. Kew, Surrey, Royal Botanic Gardens.

Langenheim, J. H. 1990. Plant Resins. *American Scientist* **78**: 16-24.

Langenheim, J. H. 1994. Higher plant terpenoids: A phytocentric overview of their ecological rles. *Journal of Chemical Ecology* **20**: 1223-1280.

Langenheim, J. H. 1995. Biology of amber-producing trees: Focus on case studies of Hymenaea and Agathis *in Amber, Resinite, and Fossil Resins*. K. B. Anderson and C. J. Krelling [eds.] American Chemical Society Symposium Series, No. 617: 1-31.

Langenheim, J. H. and C. A. Balser. 1975. Botanical origin of resin objects from aboriginal Costa Rica. *Vículos: Revista de Antropología del Museo de Costa Rica* **1**(2): 72-82.
Langenheim, J. H. and C. W. Beck. 1965. Infra-red spectra as a means of determining botanical sources of amber. *Science* **149**: 52-55.
Langenheim, J. H. and C. W. Beck. 1968. Catalogue of infrared spectra of fossil resins (ambers): I. North and South America. *Harv. Univ. Bot. Mus. Leaflets* **22**: 65-120.
Langenheim, J. H., C. E. Foster, D. E. Lincoln, and W. H. Stubblebine. 1978. Implications of variation in resin composition among organs, tissues and populations in the tropical legume *Hymenaea. Biochemical Systematics and Ecology* **6**: 241-313.
Langenheim, J. H. and Y.-T. Lee. 1974. Reinstatement of the genus *Hymenaea* (Leguminosae: Caesalpinioideae) in Africa. *Brittonia* **26**: 3-21.
Langenheim, J. H., Arrhenius S. and Nascimento J. C. 1981. Relationship of light intensity of leaf composition and yield in the tropical leguminous genera *Hymenaea* and *Copaifera. Biochemical Systematics and Ecology* **9**: 27-37.
Lerdau, M. and J. Gershenzon. 1977. Allocation Theory and Chemical Defense *in Plant Resource Allocation*. F. Bazzaz, A. and J. Grace[eds.]. San Diego, Academic Press.
Lewis, W. H. and M. P. F. Elvin-Lewis. 1977. *Medical Botany: Plants Affecting Man's Health*. New York, Wiley & Sons.
Lockhart, L. A. 1990. Chemotaxonomic relationships within the Central American closed-cone pines. *Silvae Genetica* **39**(5-6): 173-184.
Logan, M. H. and J. Edward E. Hunt. 1978. *Health and the human condition: perspectives on medical anthropology.* North Scituate[MA], Duxbury Press.
Lounsbury, F. G. 1973. On the Derivation and Reading of the 'Ben-Ich' Prefix. *Mesoamerican Writing Systems*. E. P. Benson [ed.]. Washington, D. C., Dumbarton Oaks.
Lundell, C. L. 1933. Chicle exploitation in the sapodilla lowland of the Yucatan peninsula. *Field & Laboratory* 11(1):15-21
Lundell, C. L. 1937. *The vegetation of Peten. With an appendix: Studies of Mexican and Central American plants--I.* Publication 478. Washington, D. C., Carnegie Institute of Washington. 436: 253-355.

Lundell, C. L. 1939. Plant probably utilized by the Old Empire Maya of Peten and adjacent lowlands. *Papers of the Michigan Academy* 24:37-56.
Lundell, C. L. 1940. Botany of the Maya Area. *Miscellaneous Papers XIV-XXI*. Publication 522. Washington, D.C., Carnegie Institute of Washington.
Lundell, C. L. 1961. Plantae Mayanae-II: Collections from Peten and Belice. *Wrightia* 2(3):111-126.
Mabberley, D. J. 1997. *The Plant Book*. Cambridge, Cambridge University Press.
Mann, J. 1987. *Secondary Metabolism*. 2ed. New York, Oxford University Press, 1987.
Mantell, C. L., Kopf, C. W. Curtis, J. L. Rogers, E. M. 1942. *The Technology of Natural Resins*. New York, John Wiley.
Martínez , M. 1959a. *Las Plantas Medicinales en Mexico*. Mexico, Ediciones Botas.
Martínez , M. 1959b. *Plantas Utiles de la Flora Mexicana*. Mexico City, Ediciones Botas.
McBryde, F. W. 1948. *Cultural and Historical Geography of Southwest Guatemala*. Washington, D. C., Government Printing Office.
McDoniel, P. B. and J. R. Cole. 1972. Antitumor activity of *Bursera schlechtendalli* (Burseraceae): Isolation and structure determination of two new lignans. *Journal of Pharmaceutical Sciences* **61**(12): 1992-1994.
McGee, R. J. 1990. *Life, Ritual, and Religion Among the Lacandon Maya*. Belmont [CA], Wadsworth.
McVaugh, R. and J. Rzedowski. 1965. Synopsis of the genus *Bursera* L. in western Mexico, with notes on the material of *Bursera* collected by Sessé and Mociño. *Kew Bulletin* **18**: 317-346.
Metcalfe, C. R. 1967. Distribution of latex in the plant kingdom. *Economic Botany* **21**: 115-125.
Mills, J., and R.White. 1977. Natural Resins of Art and Archaeology. Their Sources, Chemistry, and Identification. Studies in Conservation. **22**(1).
Mirov, N. T. 1967. *The Genus Pinus*. New York, Ronald Press.
Monardes, N. 1925 [1574]. *Joyfull Newes Out of the Newe Found Worlde*. London and New York, Constable and Co., Alfred A. Knopf.

Montero Miranda, F. F. 1954. Descripción de la Provincia de la Verapaz por Fray Francisco Montero de Miranda. *Sociedad de Geografia y Historiade Guatemala Añales* **27**: 342-358.
Moore, M. 1989. *Medicinal Plants of the Desert and Canyon West*. Santa Fe, Museum of New Mexico Press.
Morton, J. F. 1977. *Major Medicinal Plants: Botany, Culture, and Uses*. Springfield [IL], Charles C. Thomas.
Orellana, S. 1987. *Indian Medicine in Highland Guatemala: The Prehispanic and Colonial Periods*. Albuquerque, University of New Mexico Press.
Oviedo, Gonzales Fernández de. 1959 [1526]. *Natural History of the West Indies*. Chapel Hill, University of North Carolina Press.
Parra Novo, J. C. 1995. *Persona y Communidad Q'eqchi'*. Cobán [Guatemala], Textos Ak' Kutan.
Pacheco, P. Luis. 1988. *Tradiciones y Costumbres del Pueblo Maya Kekchi:Noviazgo, Matrimonio, Secretos, etc*. San José [Costa Rica], Editorial Ambar.
Perry, J. P., Jr. 1991. *The Pines of Mexico and Central America*. Portland [OR], Timber Press.
Peterson, A. A. and T. A. Peterson. 1992. Aztec exploitation of cloud forests: tributes of liquidambar resin and quetzal feathers. *Global Ecology and Biogeography Letters* **2**: 165-173.
Pollard, A. M. and C. Heron. 1996. *Archaeological Chemistry*. Cambridge, England, The Royal Society of Chemistry.
Ponsinet, G., G. Oueisson and A. C. Oehlschlager. 1968. Systematic aspects of the distribution of di- and triterpenes. *Recent Advances in Phytochemistry*. T. Mabry [ed.]. New York, Appleton-Century. **24**: 271-304.
PROCOMITH [Programa de Colaboración Sobre Medicina Indigena Tradicional y Herbolaria]. 1990. *La Herbolaria Médica Tzetzal-Tzotzil en los Altos de Chiapas: Un Ensayo Preliminar Sobre las Cincuenta Especies Botánicas de Uso Más Frecuente*. Tuxtlas Guttiérrez, Chiapas, PROCOMITH.
Ramírez, Jose. 1902. *Catálogo alfabetico de nombres vulgares y científicos de plantas que existen en México*. Mexico, Secretaria de Agricultura y Fomento. Dirección de Estudios Biológicos.

Ramos, G. S. and E. M. Engleman. 1982. Estudio de los canales resiniferos de la corteza de *Bursera copallifera* and *Bursera grandifolia*. *Boletin de la Sociedad Botanica de Mexico* **42**: 41-54.
Record, S. J. 1921. Further notes on intercellular canals in dicotyledonous woods. *Journal of Forestry* **19**: 255-266.
Record, S. J. and Y. W. Hess. 1943. *Timbers of the New World*. New Haven, Yale University.
Reis Altschul, von, S. 1973. *Drugs and Foods From Little-Known Plants: Notes in Harvard University Herbaria*. Cambridge [MA], Harvard University Press.
Reis, von, S. and F. J. Lipp, Jr. 1982. *New Plant Resources for Drugs and Foods from the New York Botanical Garden Herbarium*. Cambridge [MA], Harvard University Press.
Restall, M. 1998. *Maya Conquistador*. Boston, Beacon Press.
Reynolds, J. E. F., ed. 1996. *Martindale: The Extra Pharmacopoeia*. London, Royal Pharmaceutical Society.
Rosenthal, G. A. and M. R. Berenbaum, eds. 1991. *Herbivores: Their Interactions with Secondary Plant Metabolites. Vol. II, Ecological and Evolutionary Processes*. San Diego, Academic Press.
Rossells, B. 1978. Plantas y medicamentos en la medicina popular e indigena en Bolivia. *Guatemala Indigena* **13**(1-2): 150-166.
Roth, I. 1969. Características estructurales de la corteza de árboles tropicales en zonas húmedas. *Darwiniana* **15**: 115-127.
Roys, R. 1976. *The Ethno-Botany of the Maya*. Philadelphia, Institute for the Study of Human Issues.
Roys, R. L. 1931. *The Ethno-Botany of the Maya*. New Orleans, Tulane University.
Rzedowski, J. 1970. Notas sobre el genero *Bursera* (Burseraceae) en el estado de Guerrero (Mexico). *Annales de la Escuela Nacional de Ciencias Biologicas*. **17**:17-36.
Rzedowski, J. 1994. *Vegetación de Mexico*. Mexico, D. F., Editorial Lincusa
Rzedowski, J. and F. Guevara-Fefer. 1992. *Flora del Bajio y de regiones adyacentes. Fasciculo 3. Familia Burseraceae*. Patzcuáro, Michoacán, Mexico, Instituto de Ecología, A. C., Centro Regional del Bajio.
Rzedowski, J. and H. Kruse. 1979. Algunas tendencias evolutivas en *Bursera* (Burseraceae). *Taxon* **28**: 103-116.

Rzedowski, J. and E. Ortiz. 1982. Estudios quimotaxonomicas de *Bursera* (Burseraceae) I. *Bursera chemapodicta* sp. n. *Boletin de la Sociedad Botanica de Mexico* **43**: 73-80.
Rzedowski, J. and E. Ortiz. 1988. Estudios quimotaxonomicos de *Bursera* (Burseraceae). II. Una especie nueva de origen hibrido de la Barranca de Tolantongo, Estado de Hidalgo. *Acta Botanica Mexicana* **1**: 11-19.
Sahagún, B. d. 1950-1982. *General History of the Things of New Spain: Florentine Codex*. Santa Fe and Salt Lake City, School of American Research and University of Utah Press.
San Feliciano, A. and J.-L. López. 1991. Recent chemistry of conifer terpenoids in *Ecological Chemistry and Biochemistry of Plant Terpenoids*. J. B. Harborne and F. A. Tomas-Barberan [eds.]. Oxford, Clarendon Press.
Sapper, K. 1985. *The Verapaz in the Sixteenth and Seventeenth Centuries: A Contribution to the Historical Geography of Northeastern Guatemala*. Los Angeles, Institute of Archaeology, University of California, 13, Occasional Paper.
Schele, L. and M. Miller. 1986. *The Blood of Kings: Dynasty and Ritual in Maya Art*. Fort Worth, Kimbell Art Museum.
Scholes, F. V. and R. L. Roys. 1968. *The Maya Chontal Indians of Acalan-Tixchel: A Contribution to the History and Ethnography of the Yucatán Peninsula*. Norman, University of Oklahoma Press.
Schultes, R. E. and R. F. Raffauf. 1990. *The Healing Forest: Medicinal and Toxic Plants of Northwest Amazonia*. Portland [OR], Dioscorides Press.
Smith, N. J. H., J. T. Wiliams, Donald L. Plucknett, Jennifer P. Talbot. 1992. *Tropical Forests and Their Crops*. Ithaca, Cornell University Press.
Soto Nuñez, J. C. and Sousa S., M. 1995. *Plantas Medicinales de la Cuenca del Río Balsas*. Mexico City, Instituto de Biología, UNAM.
Standley, P. C. 1982 [1920-1926 reprint]. *Trees and Shrubs of Mexico*. Vaduz (Germany), Strauss & Cramer.
Standley, P. C. and J. A. Steyermark. 1946-. Flora of Guatemala. *Fieldiana. Botany*. Publication, 577. **24**(pt. 1-13).
Stross, B. 1994-1996. Mesoamerican copal resins. *U Mut Maya. Reports and Readings Inspired by Linda Schele at the University of Texas at Austin, 1994-1996.*
Tax, S. 1937. The municipios of the midwestern highlands of Guatemala. *American Anthropologist* (July-Sept.): 423-444.
Tedlock, B. 1992. *Time and the Highland Maya*. Alberquerque, University of New Mexico Press.

Tedlock, D. 1985. *Popul Vuh: The Mayan Book of the Dawn of Life*. New York, Simon and Schuster.
Thomas, B. R. 1970. Modern and fossil plant resins *in Phytochemical Phylogeny*. J. B. Harborne [ed.]. London and New York, Academic Press: 59-79.
Tozzer, A. F. 1941. *Landa's Relación de las Cosas de Yucatan*. Cambridge [MA], Harvard University.
Tozzer, A. M. 1907. *A Comparative Study of the Mayas and Lacandones*. New York, Published for the Archaeological Institute of America, Report of the Fellow in American Archaeology, 1902-1905, by MacMillan Co.
Tozzer, A. M. 1978. *A Comparative Study of the Mayas and the Lacandones*. New York, AMS Press.
Tozzer, Alfred M. 1984. *A Spanish Manuscript Letter on the Lacandones*. Additional notes by Frank E. Comparato. Lancaster [CA], Labyrinthos
Tyler, V. E., L. R. Brady and J. E. Robbers. 1976. *Pharmacognosy*. Philadelphia, Lea & Febiger.
Van Die, J. 1955. A comparative study of the particle fraction from Apocynaceae latices. *Ann. bogor.* **2**: 1-124.
Ventura, C. 1996. The symbolism of Jakaltek Maya tree gourd vessels and corn drinks in Guatemala. *Journal of Ethnobiology* **16**(2): 169-183.
Vogel, V. J. 1970. *American Indian Medicine*. Norman, University of Oklahoma Press.
Vogt, E. 1976. *Tortillas for the Gods: A Symbolic Analysis of Zinacanteco Rituals*. Cambridge [MA], Harvard University Press.
Webber, E. I. 1941. Systematic anatomy of the woods of the Burseraceae. *Lilloa* **6**: 441-465.
Weiss, J. 1998. Diagnostic Concepts and Medicinal Plant Use of the Chatino (Oaxaca, Mexico) with a Comparison of Chinese Medicine. Ph. D. dissertation. Botany Department, University of Texas, Austin, Texas.
Wells, F. V. and M. Billot. 1981. *Perfumery technology: art, science, industry*. Chichester & New York, E. Horwood, Halsted Press (distributor).
Williams, L. O. 1981. The Useful Plants of Central America. *Ceiba* **24**:1-381.
Werker, E. Y. and A. Fahn. 1969. Resin ducts of *Pinus halapensis* Mill. Their structure, development and pattern of arrangement. *Journal of the. Linnean Society of Botany.* **62**: 339-411.
Wilson, R. 1995. *Maya Resurgence in Guatemala: Q'eqchi' Experiences*. Norman & London, University of Oklahoma Press.

Wisdom, C. 1940. *The Chorti Indians of Guatemala*. Chicago, University of Chicago Press.

Wren, R. C. 1998. *Potter's New Cyclopedia of Botanical Drugs and Preparations*. Saffron Walden [Essex], C. W. Daniel Co.

Ximénez, F. F. 1967. *Historia Natural de Reino de Guatemala (1772)*. Guatemala City, Pineda Ibarra.

Zavarin, E. 1968. Chemotaxonomy of the genus *Abies*. *Phytochemistry* 7:92-107.

Vita

Kirsten Tripplett was born in North Tarrytown, New York, on March 16, 1963, to Glenn and Pat Tripplett. Shortly after her birth Kirsten moved to Florida. At the age of five, she moved to Millwood, New York, where she dissected her first flower. She attended Horace Greeley High School, Chappaqua, New York, and lived in Manhattan part-time until she graduated in 1982. She became an assistant manager at a health food store in Mt. Kisco, New York, and developed in interest in herbal remedies and their uses. In 1984 Kirsten was accepted to and attended College of the Atlantic in Bar Harbor, Maine. While there she attended the Tropical Forest Ecology Program at the Manomet Bird Observatory in Manomet, Massachusetts and assisted Dr. Nick Brokaw in a study of the community structure of primary rainforest in the Maya Mountains, Toledo District, Belize, which was later published. In June, 1988, Kirsten was chosen by Dr. Richard Primack and Pamela Hall, of Boston University, to be a field assistant in a study of forest structure and regeneration in Sarawak, Malaysia, for three months. Kirsten completed her senior thesis on the relationship between the World Bank and rainforest development in Brazil and graduated from College of the Atlantic in May, 1989, with a Bachelor of Arts in Human Ecology. In 1989 she was awarded a Plant Systematics Grant from the Department of Botany, University of Florida, to attend an intensive program in tropical botany at Fairchild Garden, Coral Gables, Florida, for the summer of 1989. In October, 1989, Kirsten married John Oliver, and they moved to Westport, Massachusetts, where Kirsten became a licensed professional nurseryman and studied horticulture at the Arnold Arboretum.

Kirsten entered the Botany program at The University of Texas at Austin in 1991, where she was a teaching assistant for four years. She spent a total of six months in Guatemala, studying Maya language and culture, collecting plant exudates, establishing a field site, and conducting field work. Her dissertation work was supported by grants from: Sigma Xi Grant-In-Aid; the Institute of Latin American Studies Faculty-Sponsored Dissertation Grant; Systematics Research Grants from the Department of Botany, University of Texas at Austin; Travel Grant, the Institute of Latin American Studies, University of Texas at Austin; and the Turner Fellowship Fund, Department of Botany, University of Texas atAustin. She has recently accepted a position at the Maya Research Program, Blue Creek, Belize, as staff ethnobotanist.

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