Pergamon

PII: S0277-9536(98)00181-6

*Soc. Sci. Med.* Vol. 47, No. 11, pp. 1859–1871, 1998

Printed in Great Britain
0277-9536/98/$ - see front matter

# MEDICINAL PLANTS IN MEXICO: HEALERS' CONSENSUS AND CULTURAL IMPORTANCE

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**Abstract**—Medicinal plants are an important element of indigenous medical systems in Mexico. These resources are usually regarded as part of a culture's traditional knowledge. This study examines the use of medicinal plants in four indigenous groups of Mexican Indians, Maya, Nahua, Zapotec and – for comparative purposes – Mixe. With the first three the methodology was similar, making a direct comparison of the results possible. In these studies, the relative importance of a medicinal plant within a culture is documented using a quantitative method. For the analysis the uses were grouped into 9–10 categories of indigenous uses. This report compares these data and uses the concept of informant consensus originally developed by Trotter and Logan for analysis. This indicates how homogenous the ethnobotanical information is. Generally the factor is high for gastrointestinal illnesses and for culture bound syndromes. While the species used by the 3 indigenous groups vary, the data indicate that there exist well-defined criteria specific for each culture which lead to the selection of a plant as a medicine. A large number of species are used for gastrointestinal illnesses by two or more of the indigenous groups. At least in this case, the multiple transfer of species and their uses within Mexico seems to be an important reason for the widespread use of a species. Medicinal plants in other categories (e.g. skin diseases) are usually known only in one culture and seem to be part of its traditional knowledge. © 1998 Elsevier Science Ltd. All rights reserved

*Key words*—medicinal plants, traditional medicine, self-medication, *inter*cultural comparison, Mexican Indian, informant consensus, ethnobotany

## INTRODUCTION

Most studies on medicinal plants focus on the role of these plants within *one* culture, i.e., one ethnic group. Little emphasis has been given to the comparison of medicinal plant species or other higher taxa (family, genera) in various cultures (cf. Heinrich, 1996; Moerman, 1996). Despite this neglect, a cross-cultural comparative approach has had a strong influence in anthropology (Harris, 1968) and especially in medical anthropology (e.g. Jordan, 1979; Lock, 1993). This study has therefore sought to examine the use of medicinal plants in four indigenous groups of Mexican Indians. With each group, representing a separate study, the methodology was identical except for the first study (Lowland Mixe), which was conducted prior to the other three. Work was conducted in collaboration with healers from the Isthmus Sierra Zapotecs, Oaxaca (Frei *et al*., 1998), the Yucatec Maya, Yucatán (Ankli *et al*., n.d.) and the Nahua of the Sierra de Zongolica, Veracruz (Weimann and Heinrich, 1997, 1998). There are two alternatives when examining the use of medicinal plants: consensus and variation. Therefore an analysis of the plant usage must be performed in order to understand the patterns of use *intra- and interculturally*. Medicinal plants are not selected at random, but exhibit a considerable degree of patterning within one culture. The principal reason for this is empiricism; i.e. plants are selected and used in a consistent manner because of their culturally perceived effectiveness (Trotter and Logan, 1986; Trotter, 1981; Heinrich, 1998).

In recent years we have called attention to the lack of information on the *relative importance* of a medicinal plant (or other useful plant) within a culture and the need for *comparing the use of plants interculturally* (Heinrich *et al*., 1992; cf. Etkin, 1994; Moerman, 1996; for records of such data without an analysis see Amo, 1979; Alcorn, 1984; Aguilar *et al*., 1994). This paper specifically deals with medicinal plants, the relative role of the taxa used in the respective cultures and the relevance of these plants in the treatment of the diseases prevalent in the areas. A constructive method to obtain such information is the quantification of indigenous uses (Phillips, 1996; see also Phillips *et al*., 1994; Ngokwey, 1995). This is useful if the relative importance of each use is similar, as with medicinal plants used for different types of illnesses. This also forms the basis for studies in which the indigenous therapeutic claims are evaluated and in which some

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of the active constituents are isolated and their structures elucidated (Farnsworth, 1990; Kato *et al.*, 1996; Bork *et al.*, 1997).

Therefore the three ethnobotanical studies, which serve as the principal basis for this paper, employ similar methodologies (see also Section 2).

- Specialists in medicinal plants (for example, healers, midwives, herbalists) were interviewed during 14–18 months of fieldwork and the use-reports of each informant for the plants were recorded.
- The use of the plants were grouped into 9 or 10 categories (called categories of use). The principal categories are similar in all three studies: gastrointestinal, dermatological (mostly infections and subsequent inflammatory reactions), respiratory, gynaecological (and andrological) conditions. Since there are ethnomedical differences among the 3 ethnic groups, up to 6 additional categories were formed which pertain to only one or two of the groups. For example, the category for "poisonous animal bites and stings" applies only to the Maya; ophthalmological illnesses only to the Maya and Zapotecs; and culture-bound syndromes only to the Nahua and Zapotecs.
- For each category the data were quantified by adding up the individual reports on the uses of each plant (see Ankli *et al.*, n.d.; Frei *et al.*, 1998; Weimann and Heinrich, 1997). They were then ranked according to the *number of reports* of use. We thus obtained information on the *intra*cultural importance of a species.

Here the subsequent analysis is presented, which compares the relative importance of the taxa in the various categories of indigenous uses (the *inter*cultural analysis). This comparative method allows not only the selection of indigenous medicinal plants for phytochemical and biological/pharmacological studies, but is also useful in determining the cultural importance of a particular plant as opposed to others in the same usage category. There have been several other approaches to establish quantitative criteria for the relative importance of plants (Friedman *et al.*, 1986; Johns *et al.*, 1990; Phillips, 1996; Berlin and Berlin, 1996). The one of Berlin and Berlin is of particular relevance to the discussion here. These authors used a largely similar approach, however, with the help of field assistants they interviewed the general population and thus recorded and evaluated an enormous set of positive responses: approximately 30,000 (Berlin and Berlin, 1996, 81–82). Their method requires a considerable investment in research funds and personnel. The method presented here is tailored to allow for the assessment of the relative cultural, medical, and consequently, the socio-economic importance of plants employed by medical specialists in an ethnic group. The earlier project on the Lowland Mixe is also based on a similar methodology, but the data were not quantified systematically. Instead, an estimation of the relative importance of the respective taxa was made (Heinrich, 1989).

## BACKGROUND AND METHODS

### *General*

All studies were conducted in Mexican Indian communities in the southern parts of Mexico (see Table 1 and Fig. 1). The Indian groups included belong to the Yucatec Maya, Lowland Mixe, Nahua of the Sierra de Zongolica and Sierra Isthmus Zapotec. Generally speaking, these regions are in the more marginal regions of Mexico. Emigration is frequent, especially with regard to the Zapotecs and Nahua. In all four groups subsistence agriculture is the economic basis, with corn being the main crop. Other important crops vary from region to region.

Indigenous forms of medical treatment are still important. One of the main reasons is the lack of biomedical facilities in the communities and the indigenous peoples distrust towards allopathic medical doctors. Indigenous medical specialists –as the term is used in this paper– includes not only those people who are considered to be a healer by the community, but also people who state that they only know *some* herbal remedies and who advise members of the community on how to use them ("specialists in home remedies", cf. Heinrich, 1994) and who may perform ritual cleansing ceremonies (*limpias*). According to the unpublished data of the local health authorities and our surveys, it is apparent that gastrointestinal disorders (frequently diarrhoea and –especially in younger children– as a result thereof, dehydration) and respiratory illnesses are major health problems in all regions. Infected wounds and other inflammatory dermatological diseases are also common.

### *Maya*

The data on the Maya were gathered in the communities of *Chikindzonot* (pop. 1500), its neighboring community *Ekpetz* (pop. 800) and *Xcocmil* (150) which lie south of the city of Valladolid in the southeastern part of the state of Yucatán (for details, see Ankli *et al.*, n.d.). The entire *municipio* of Chikindzonot numbers 2750 inhabitants. 56% of those older than 15 y are literate and one third of those older than five years are monolingual speakers of Maya, with the remainder being bilingual. The economy is based on subsistence agriculture (mostly maize, beans and squash), as well as honey, fruit (watermelon and citrus fruits) and cattle breeding. Hunting is still practiced regularly, especially by younger men. Handicraft articles (hammocks and *huipiles*, a women's blouse) are sold in the market of Valladolid. No detailed anthropological monograph on the Maya of this area is available,

Table 1. Summary of ethnographic background, medical ethnobotany and medical system for the four cultures

| Culture (ethnic group) | Maya | Nahua | Zapotec | Mixe |
|---|---|---|---|---|
| | | Ethnographic background | | |
| Subsistence agriculture with maize as the main staple | + | + | + | + |
| Commercially important crops | | | | |
| – coffee | – | + + | + + | + |
| – citrus fruits | (+) | (+) | + | + |
| – vegetables/legumes | (+) | + | + | – |
| Other important economic activities | | | | |
| – handicraft (production of huipiles) | + | – | – | + |
| (Bilingual or monolingual) speakers of the indigenous language (in %) | 99 | 70 | 60 | 90 |
| Activities of Protestant groups | weak | medium | strong | strong |
| Emigration | (+) | + | + | (+) |
| | | Information on medicinal plants | | |
| Total number of botanical species documented | 320 | 203 | 445 | 213 |
| Total number of use-reports obtained | 1549 | 816 | 3059 | n.a. |
| | | Medical system | | |
| Permanent presence of Western trained medical doctors (private or state-employed, seven days/week) | – | + | – | – |
| Important groups of indigenous healers | | | | |
| – specialists in home remedies | + | + | + | + |
| – midwives | + | + | + | + |
| – specialists in medicinal plants | + | + | + | + |
| – diverse types of ritual specialists | + | + | + | + |
| – bonesetters | + | (+) | + | + |
| – spiritists and/or spiritualists | – | (+) | + | (+) |
| Hot–cold classification important for medicinal plants | (+) | + | + + | – |
| Classification based on taste and smell properties | + | (+) | + | + |
| Classification based on symbolic characteristics of plants | (+) | (+) | + | (+) |

n.a. = data not available, + + = very important or frequent, + = relevant aspect of the culture, (+) = only of minor importance, – = not present in the region at the time of the study.

but the community of *Chan Kom*, which was first studied by Redfield and Villa Rojas (1934), is only 27 km to the north.

*Health and healing*. Poisonous snakebites (from species such as *tsab* –cascabel– *Crotalus durissus*) are feared but only a few cases have been recorded in recent years. Diabetes is considered a critical health problem by local health authorities, and elderly women often claim to suffer from it.

The best known group of healers is the *h-men*. They are not only healers but also religious specialists who perform ceremonies in order to request rain for the *milpa* (cornfield) from the rain-god or to pray for other needs of the community. He or she is the owner of a *sastun*, a stone used for divining. Midwives and *hierbateros* (specialists in medicinal plants) form another group of healers. The medicinal plant specialists are generally proficient in treating broken bones as well, and thus work as *hueseros*. The *sobadores* give massages along with the midwives. All these groups of healers extensively use medicinal plants. Some use these plants almost entirely as empirical medications, while others (in particular the *h-men*) also use them for ritual purposes.

An outpatient clinic run by the SSA (*Secretaría de Salud y Asistencia*) and staffed with a *pasante* (a medical student in the final year of training) and a *mestizo* nurse provides biomedical health care in Chikindzonot. For most ailments, however, the Maya still prefer to be treated by their own healers. In 1993/1994 the *pasante*, although a woman, was called only once to assist a delivery. Ethnomedical and ethnobotanical data were collected from February 1994 until May 1995, and in September–October, 1996.

### *Mixe*

The land of the Mixe extends mostly through the cool and humid mountains of the *Sierra de Juarez* in the Mexican state Oaxaca. *San Juan Guichicovi* is the only Mixe-speaking community in the subtropical *Istmo de Tehuantepec*. It is the principal community (*cabecera*) in a subdistrict (*municipio*) of the same name. In 1980, the *municipio* had 20,000 inhabitants, while the *cabecera* 5500 to 6500 (Heinrich *et al*., 1992). 75% of the population in the *cabecera* are considered to be bilingual. A minute fraction of the population can only speak Spanish. The economy is based on subsistence agriculture (mainly maize) and on the production of coffee and citrus fruit. Another relevant commercial product are *huipiles* of the Tehuantepec style. They are produced by women and men of the community and are usually sold to Isthmus Zapotec merchant women who resell them in numerous communities


Fig. 1.

of the Oaxacan part of the Isthmus and in many other regions of Mexico. No detailed monograph on the lowland Mixe is available. Two cultural aspects that have been dealt with in detail are the ritual calendar, which is still used in some parts of the *municipio* (Weitlaner Johnson and Weitlaner, 1963) and, in some adjoining *municipios*, the relationship of religious ritual to medical concepts (Lipp, 1991).

*Health and healing*. There are at least 15 different types of healers (*pa'am iixyp'*) known in the community. The largest groups are "specialists in home remedies". Other important groups are midwives, *chupadores* (healers that suck out an illness), prayer makers (*rezadores*), spiritists (*espiritistas*) and spiritualists (*espiritualistas*). Considerable differences distinguish the various groups of healers (Heinrich, 1994, 1998). Recently, the number of those offering help in case of illness has grown to include travelling salespersons (mostly Mixe-speakers with minimal experience in Western medicine), assistants to the local Roman Catholic priest, various Protestant groups and trained nurses. The differences between these health care providers are enormous. The travelling salespersons and other individuals with minimal experience in Western medicine are best considered as charlatans, while others have a solid background in medical therapy. Over the past 10 y, there have always been one to four practising medical doctors present. Some are medical doctors sent by Mexican government agencies such as IMSS (*Instituto Mexicano del Seguro Social*) and INI (*Instituto Nacional Indiginista*). Some of the specialists in home remedies and travelling salespersons sell pharmaceuticals and give advice on how to administer them. No quantitative data are available on the importance of these forms of medication as opposed to indigenous phytotherapy. Data in this area were collected in 1985 and 1986, and later in several short trips (1–2 months).

### *Nahua*

The *Sierra de Zongolica* in the Mexican state of Veracruz is part of the *Sierra Madre Oriental*. Its area of 1900 km$^2$ lies to the south of 19° N latitude, and is bordered by the states of Puebla and Oaxaca. The area is subdivided according to altitude into three major regions: the cold highlands (*tierra fría*), temperate intermediate zone (*tierra templada*) and hot lowlands (*tierra caliente*). Oak and conifer forests dominate the vegetation in the cold highlands, whereas in the hot lowlands the principal ecosystem is the tropical evergreen forest.

There are about 200,000 inhabitants in the Sierra and 34,000 in the subdistrict (*municipio*) of *Zongolica* (Weimann and Heinrich, 1997). Since the 19th century the commercial production of coffee has played the dominant economic role. Many different fruits and vegetables are cultivated and occasionally the forest trees are cut for wood. In past decades, tobacco was an important crop. The people of the hot and cold zones are mutually dependent on each other; for example, workers from the cold zone come to the lowlands to earn an annual subsistence.

Nahuatl, belonging to the Uto–Aztecan language families, is still spoken by a large portion of the population. More than 90% of the population in the highlands are mono- or bilingual speakers of Nahuatl while in the lowlands it is approximately 70%.

*Health and healing*. The most frequent disorders are gastrointestinal and respiratory. Tuberculosis is still prevalent. *Mal aire*, which is said to be caused by an evil spirit or wind, and *susto*/*espanto* (sudden fright) are culturally important medical problems. Symptoms of the latter may be sleeplessness (despite of being tired) and/or shivering fits. We often encountered reports of unexplained gastrointestinal disorders.

The Nahuatl have various groups of specialists for curing illness. Ritual healers (*curanderos*) treat culture-bound syndromes. Midwives accompany women throughout the pregnancy, birth and childbed. The *hierberos* are specialists in medicinal plants. The *hueseros* are experts on the skeleto-muscular system and deal with sprains, fractures and bruises. Many healers have had experience in several forms of treatment. Ethnomedical and ethnobotanical data were collected in selected regions of the Sierra Nahua de Zongolica from September 1993 until February 1995. In this area, biomedical forms of treatment were more readily available than in the other three regions.

### *Zapotec*

The area of the *Zapotecs* is adjacent to the one of the Mixe. Forced in the 14th century by Aztec and Mixtec invasions to leave the highland Valley of Oaxaca, the Sierra Zapotecs settled in their present area. The communities we worked with, especially *Santo Domingo Petapa* and *Santa María Petapa*, are linguistically and culturally isolated from the other Sierra Zapotec groups. One to five percent of the inhabitants older than five years are monolingual speakers of Zapotec, and 50–70% are bilingual. As with the Mixe, coffee and citrus fruits are important commercial products.

*Health and healing*. The spectrum of illnesses known to the Zapotecs is similar to that of the Mixe (see above). In addition, many of the groups of healers are similar to those described for the other groups: specialists in home remedies, midwives, herbalists (*hierberos*). Bonesetters are still active in the communities and in the treatment of sprains, fractures, and bruises. Many healers have experience in several forms of treatment. Gastrointestinal and dermatological conditions are the two groups of illnesses treated most frequently with herbal preparations. The treatment is largely based on the principle of binary opposition using a hot–cold classification (Frei *et al*., 1998).

### *Ethnobotanical methods and documentation*

By interviewing specialists in medicinal plants and other healers from the different regions we obtained information on the use, preparation, application and properties of the plants as well as descriptions of illnesses and treatments. We did unstructured interviews and discussions on medicinal plants and the modes of treatment at meetings of groups of indigenous healers. Sometimes other community members were present. The reports from the healers for each species were summarized up and yielded the numbers given in parentheses in Tables 3–5. Further data are based on participant observation, especially on the observation of the healers' healing sessions and of self-treatment.

Voucher specimens for all our studies are deposited at the Herbarium of the *Universidad Nacional Autonoma de México* (MEXU) and the *Institut für Pharmazeutische Biologie* (Freiburg, FRG). Collections from individual studies are at the Herbarium of the *Instituto de Ecología* (XAL, Xalapa, Veracruz, Mexico) (Nahua collection), the *Centro de Investigación Científica de Yucatán* (CICY, Mérida, Yucatán, Mexico) (Maya collection), the *Herbario Medicinal del Instituto Mexicano del Seguro Social* (IMSS-M, México, D.F.) (Nahua and Mixe collections), the ETH Zürich (ZT, Zurich, Switzerland) (Maya and Zapotec collections). The collection numbers are A. Ankli 1-450, C. Weimann 1-324, B. Frei 1-550, M. Heinrich and N. Antonio B. 1-350. Plants were determined by comparison with authentic specimens and in some cases with the assistance of several specialists at the National Herbarium of Mexico.

## RESULTS AND DISCUSSION

The number of taxa recorded in the three studies (Zapotec, Maya, and Nahua) and the total number of use-reports (number of informants that report the use of this species) in these studies varies greatly among the three sites (see Table 1). This variation reflects the different amount of time that was required to built up a trusting relationship with key informants, the distance between the principal field location of the plants and the homes of the informants, as well as the number of key informants who collaborated with us. Generally in all three groups, the medicinal plants most frequently mentioned serve toward the treatment of gastrointestinal and dermatological conditions. These two categories yielded the largest number of individual use-reports. For the Maya and Nahua, the greatest number of use-reports dealt with gastrointestinal illnesses. In addition, the Maya used more plant species for these disorders than the other groups. For the Zapotecs, the largest number of taxa and use-reports were concerned with dermatological conditions. Other categories of illness that are frequently treated with herbal preparations are culture-bound syndromes (Zapotecs), respiratory illnesses, gynaecological/andrological conditions (all three groups) as well as pain and fever. Further categories were created to accommodate illnesses which were specific to one or two cultures or which were particularly prominent in these cultures. The data from the Maya and Nahua on pain and febrile conditions were combined since many taxa are used

Table 2. Comparison of Maya, Nahua and Zapotec medicinal plant use

| | Number of taxa | | | Number of use-reports | | | Informants' consensus factor ($F_{ic}$)[a] | | |
|---|---|---|---|---|---|---|---|---|---|
| Category of indigenous uses (group of illness) | Maya | Nahua | Zapotec | Maya | Nahua | Zapotec | Maya | Nahua | Zapotec |
| Gastrointestinal | 140 | 72 | 176 | 476 | 222 | 518 | 0.71 | 0.68 | 0.66 |
| Dermatological | 138 | 86 | 205 | 287 | 159 | 605 | 0.52 | 0.46 | 0.66 |
| Respiratory | 77 | 39 | 88 | 174 | 99 | 303 | 0.56 | 0.61 | 0.71 |
| Gynecological/ andrological | 67 | 40 | 122 | 129 | 78 | 364 | 0.48 | 0.49 | 0.67 |
| Culture-bound syndromes | – | 26 | 144 | – | 80 | 563 | – | 0.68 | 0.75 |
| Pain/febrile diseases | 105 | 56 | – | 204 | 126 | – | 0.49 | 0.56 | – |
| Fever (incl. malaria) | – | – | 76 | – | – | 285 | – | – | 0.73 |
| Skeleto-muscular | – | – | 105 | – | – | 321 | – | – | 0.68 |
| Ophthalmological | 26 | – | 20 | 39 | – | 48 | 0.34 | – | 0.60 |
| Urological | 40 | 34 | – | 66 | 67 | – | 0.40 | 0.50 | – |
| Poisonous animal bites | 42 | – | – | 76 | – | – | 0.45 | – | – |
| Cardiovascular | – | – | 20 | – | – | 52 | – | – | 0.59 |
| Other/unclassified | 60 | 11 | ca. 100 | 101 | 11[c] | n.a. | 0.41 | 0.0 | – |
| Total | 320[b] | 203[b] | 445[b] | 1549 | 816 | 3611 | | | |

n.a. = not analyzed.
– = category absent (for details see text).
[a] $\text{Factor}_{\text{informants' consensus}} = n_{(\text{use-reports}} - n_{\text{taxa}})/(n_{\text{use-reports}} - 1)$. (A higher value indicates a high rate of agreement between the informants, a low one a low degree of agreement.)
[b] A taxon may be listed in several of the categories of indigenous uses.
[c] Only diabetes.

for both types of illnesses. Two categories apply only to the Zapotecs (fever and skeleto-muscular illnesses).

Since the focus was on determining the relative homogeneity of use-reports, we compared the number of use-reports to the number of species in each category of use (see Table 2). To evaluate the variability of the use of medicinal plants and to determine whether plants from certain groups are of particular interest in the search for bioactive compounds, the informant consensus factor ($F_{ic}$) was calculated. Culturally important plants are those that are used by a large number of healers for the same category of indigenous use, while plants that are cited as useful by only one or two informants are considered to be of low cultural importance. Trotter and Logan (1986) developed a method based on the concept of "informant consensus" for identifying potentially effective medicinal plants. They compared the total case-number for each ailment (number of informants that reported a certain illness) with the number of separate remedies for this ailment. Compared to this, $F_{ic}$ gives the relationship between the "number of *use-reports in each category* ($n_{ur}$) minus the number of taxa used ($n_t$)" and the "number of *use-reports in each category* minus 1".

*To facilitate the reading of the text, common English terms for species (following Morton, 1981) have been added in the main body of the paper (but not in the tables) along with their botanical names. The authorities of plant names have been omitted in this paper, but can be found in the four monographs on plant use of the groups studied. Indigenous names were recorded and can be found on the voucher specimens.

$F_{ic}$ is thus calculated using the following formula:

$$F_{ic} = \frac{n_{ur} - n_t}{n_{ur} - 1}.$$

The product of this factor ranges from 0 to 1. A high value (close to 1) indicates that relatively few taxa (usually species) are used by a large proportion of the healers, while a low value indicates that the informants disagree on the taxa to be used in the treatment within a category of illness. Generally $F_{ic}$ is higher among the Zapotecs. This indicates a more consistent use of the medical resources. A category of use that yielded a high factor of informant consensus were the culture-bound syndromes. For the Zapotecs, $F_{ic}$ is highest for this category (0.75), and among the Nahua it ranks first (0.68) together with gastrointestinal illnesses. These data indicate that a well-defined selection of species is culturally important for treating these illnesses. Among the Nahua the most important plant in the category "culture-bound syndromes" is pennyroyal* (*Satureja brownei*), an aromatic species which accounts for 20% of all use-reports or 12 out of 60 (Weimann and Heinrich, 1997, 1998). Among the Zapotecs nine species had ten or more use-reports, which accounts for 18.1% of all use-reports. All culturally important species are aromatic plants and rich in essential oils. Mayan culture-bound syndromes do not form a separate category, since these illnesses are not clearly distinguishable from gastrointestinal (*mal de ojo; cirro*, cf. Berlin *et al.*, 1993 and see Table 7) or skeleto-muscular disorders or fever (*mal viento*). Also the factor is generally high in the category "gastrointestinal disorders". The core taxa in this category are shown in Table 3 (see also below and Tables 6 and 7). Once again,

Table 3. Principal species used to treat *gastrointestinal illnesses* among the Maya, Nahua and Zapotec[a] as well as comparative data from Tzeltal/Tzotzil and Mixe

| | Maya (Yucatán) | Nahua (Zongolica) | Zapotec (Istmo) | Tzeltal/ Tzotzil[b] | Mixe (Istmo) [b] |
|---|---|---|---|---|---|
| Parallel use-reports of the species with *five* indigenous groups | | | | | |
| *Chenopodium ambrosioides* | 10 | 6 | 10 | + | + |
| *Psidium guajava* | 10 | 7 | 10 | + | + |
| Parallel use-reports of the species with *four* indigenous groups | | | | | |
| *Artemisia ludoviciana* ssp. *mexicana* | 9 | 7 | 7 | | + |
| *Ruta chalepensis* | 9 | 10 | 10 | | + |
| Parallel use-reports of the species (or the genus) with *three* indigenous groups | | | | | |
| *Byrsonima crassifolia* | | | 6 | + | + |
| *Cissampelos pareira* | 9 | | | + | + |
| *Citrus* aff. *aurantifolia* | 6 | | (+) | | (+) |
| *Citrus aurantium* | 9 | | (+) | | (+) |
| *Citrus limon* | (+) | | 7 | | + |
| *Citrus sinensis* | 6 | | (+) | | (+) |
| *Lippia alba* | 9 | 9 | | | + |
| *Mentha* aff. *arvensis* | 7 | | (+) | | (+) |
| *Mentha* aff. *citrata* | 10 | | (+) | | (+) |
| *Mentha* aff. *piperita* | 18 | | (+) | | (+) |
| *Mentha* × *piperita* | (+) | | 6 | | + |
| *Psidium salutare* | | | 8 | (+) | (+) |
| *Psidium* × *hypoglaucum* | | | 6 | (+) | (+) |
| Parallel use-reports of the species (or the genus) with *two* indigenous groups | | | | | |
| *Anethum graveolens* | | | 6 | + | |
| *Artemisia absinthium* | | 6 | | | + |
| *Baccaris conferta* | | 6 | | (+) | |
| *Guazuma ulmifolia* | | | 6 | | + |
| *Matricaria recutita* | | 8 | | | + |
| *Pluchea symphytifolia* | | | 7 | | + |
| *Tagetes erecta* | | 11 | | (+) | |
| *Verbena menthaefolia* | | 7 | | (+) | |
| No parallel reports | | | | | |
| *Abrus precatorius* | 12 | | | | |
| *Annona reticulata* | | | 6 | | |
| *Aristolochia maxima* | | 11 | | | |
| *Bidens squarrosa* | 8 | | | | |
| *Callicarpa acuminata* | 9 | | | | |
| *Cissus trifoliata* | 8 | | | | |
| *Cocos nucifera* | | | 6 | | |
| *Dorstenia contrajerva* | 10 | | | | |
| *Equisetum* sp. | | | 6 | | |
| *Erigeron karvinskianus* | | 6 | | | |
| *Hylocereus undatus* | 6 | | | | |
| *Juliana adstringens* | | | 6 | | |
| *Lippia stoechadifolia* | 11 | | | | |
| *Malvaviscus arboreus* | 9 | | | | |
| *Manilkara zapota* | 12 | | | | |
| *Marrubium vulgare* | | 10 | | | |
| *Microgramma nitida* | 6 | | | | |
| *Ocinum micranthum* | 7 | | | | |
| *Phyla scarberrima* | | 6 | | | |
| *Piscidia piscipula* | 6 | | | | |
| *Punica granatum* | 7 | | | | |
| *Rosa chinensis* | | 6 | | | |
| *Triumfetta semitrilobata* | 8 | | | | |
| *Zea mays* | | | 6 | | |
| *Zingiber officinale* | 8 | | | | |

(+)Information only available for related species of the same genus.

[a]Only the species mentioned six or more times within one culture are listed.

[b]Data based on Berlin and Berlin (1996) (83), total number of principal species used in the treatment of gastrointestinal illnesses: 38 (Tzeltal/Tzotzil) and from Heinrich (1989) (36–38) (Mixe); only taxa, which were documented as important medicinal plants in at least one of the studies with the Maya, Nahua or Zapotecs (28, 12 and 15, respectively) are listed.

aromatic plants and also astringent plants, are employed by all three groups (cf. Ankli *et al*., 1998; Frei *et al*., n.d.; Weimann and Heinrich, 1997).

$F_{ic}$ is relatively low for dermatological illnesses among the Maya and Nahua indicating that there is a low consensus on the treatment of dermatological problems. This variability in use, although not quantified, was observed for the Mixe, too and is due to experimentation (Heinrich, 1989). First, new and potential medical resources are applied topically. Then, depending on the result further uses might be explored. This means that many plants initially used to treat dermatological problems are later no longer used because the plant is considered ineffective or toxic. The Zapotecs however have a well-defined category of plants used in

Table 4. Principal species used to treat *dermatological problems* among the Maya, Nahua and Zapotecs and comparative[b] data from Mixe[a]

| Maya | Nahua | Zapotec | Mixe |
|---|---|---|---|
| *Samolus ebrecteatus* (7) | *Phyllanthus niruri* (6) | *Aloe barbadensis*[c] (13) | *Aloe barbadensis*[c] |
| *Anredera vesicaria* (6) | *Lobelia laxiflora* (5) | *Tournefortia densiflora* (12) | *Capraria biflora*[c] |
| *Calea urticifolia* (6) | *Sida rhombifolia*[c] (5) | *Piper auritum*[c] (9) | *Hyptis verticillata*[c] |
| *Diospyros anisandra* (6) | *Heterotheca inuloides* (5) | *Piper tuberculatum* (7) | *Jatropha curcas*[c] |
| *Kalanchoe integra* (6) | *Anagallis arvensis* (4) | *Tithonia diversifolia*[d] (7) | *Piper auritum*[c] |
| *Ocimum micranthum* (6) | *Bryophyllum calycinum* (4) | *Capraria biflora*[c] (6) | *Sida rhombifolia*[c] |
| *Psidium sartorianum* (6) | *Buddleja cordata* (4) | *Comoclea engleriana* (6) | *Tithonia diversifolia*[d] |
| *Salvia micrantha* (6) | *Mecardonia procumbens* (4) | *Hamelia patens* (6) | |
| | *Stachys* sp. (4) | *Hyptis verticillata*[c] (6) | |
| | *Stellaria nemorum* (4) | *Jatropha curcas*[c] (6) | |
| | *Tithonia diversifolia*[d] (4) | *Pinus oocarpa* (6) | |
| | | *Solanum torvum* (6) | |
| | | *Swietina humilis* (6) | |
| | | *Thevetia thevetioides* (6) | |
| | | *Zebrina pendula* (6) | |

[a]Species mentioned six or more times (for details see text).
[b]Principal species for the Mixe based on Heinrich (1989) (46–49); and includes only taxa documented as important medicinal plants in at least one of the other studies.
[c]Parallel reports of the species (or the genus) with *two* indigenous groups.
[d]Parallel reports of the species (or the genus) with *three* indigenous groups.

the treatment of dermatological conditions. The most popular species are Aloe (*Aloe barbadensis*) and *Tournefortia densiflora* (Frei *et al.*, 1998).

There also are instances of underrepresenting the consensus of the healers. $F_{ic}$ is, for example, low for the Maya in case of gynaecological/andrological disorders. The most popular species in this category is bay cedar or *caulote* (*Guazuma ulmifolia*). It is mentioned 12 times, but is normally given in combination with other species. These species vary from informant to informant, and since these taxa are listed individually, the total number increases. Another problem are the non-identified species, since these are listed separately and thus the total number of taxa increases significantly. In the group gynaecological/andrological disorders of the collection "Maya" 29 of 67 taxa are included for which information on uses is available but which have not yet been identified.

Generally speaking, the factor $F_{ic}$ is higher among the Maya and Nahua for the larger categories of use, indicating a higher informant consensus. An increased number of use-reports does *not* result in significantly more species being added to a category. Thus the factor attests, that the number of taxa used medicinally is limited and that only a certain percentage of the total flora is used (cf. Moerman, 1996). Since no information on the total number of species in the regions is available a direct comparison is not possible. The relatively high value of $F_{ic}$ in many groups of uses indicates that the ethnobotanical sample is large enough to identify plants that are culturally important and that may be of relevance for detailed phytochemical and pharmacological studies (see Bork *et al.*, 1996). In particular, the category "gastrointestinal illnesses", which has a high $F_{ic}$ value, contains a number of potentially interesting plants (Hör *et al.*, 1995). On the other hand, due to the characteristics of culture-bound syndromes and the lack of adequate pharmacological models no attempts have been made to evaluate the claims for plants in this category using phytochemical or pharmacological methods.

Compared to Trotter and Logan's analysis (1986), it is noteworthy that several of their disease categories which have a high informant consensus value are gastrointestinal illnesses and problems, such as earache, eye irritation, insect bites, and burns treated with topical pharmaceutical preparations. Our data thus support the earlier findings of these authors and point to particularly relevant categories of uses.

### *Principal species used to treat gastrointestinal, respiratory and dermatological conditions*

In this section three different categories of indigenous use will be discussed: gastrointestinal, respiratory and dermatological. The data concerning those plants that were principally used are presented in Tables 3–5, which contain comparative data for the Mixe and (in Table 3) for the Tzeltal and Tzotzil (Berlin and Berlin, 1996).

A large number of medicinal plant species are used by two or more cultures. For example, guava (*Psidium guayava* and other species of this genus) and American wormseed (*Chenopodium ambrosioides*) are shared by 5 groups; black sage (*Artemisia ludoviciana* ssp. *mexicana*) and ruda (*Ruta chalepensis*) are employed by 4 of 5 ethnic groups. Species of 6 genera are used by 3 groups: locust berry tree or nanche (*Byrsonima crassifolia*), velvetleaf (*Cissampelos pareira*), sweet orange and related *Citrus* species (*Citrus sinensis* and spp.), cat mint (*Lippia alba*) as well as peppermint (*Mentha* × *piperita* and spp.). Eight closely related plants are utilised by any two indigenous groups (see Table 3).

Table 5. Principal species used to treat *respiratory diseases* among the Maya, Nahua and Zapotecs as well as comparative[b] data from Mixe[a]

| Maya | Nahua | Zapotec | Mixe |
|---|---|---|---|
| *Croton lundellii* (7) | *Bougainvillea glabra*[d] (9) | *Eucalyptus camaldulcensis*[c] (11) | *Bougainvillea glabra*[d] |
| *Cymbopogon citratus* (6) | *Gnaphalium ehrenbergianum*[c] (8) | *Bougainvillea glabra*[d] (10) | *Cassia fistula*[c] |
| *Ehretia tinifolia* (6) | *Anoda cristata* (6) | *Citrus limon*[c] (10) | *Citrus limon*[c] |
| *Euphorbia ptercineura* (6) | | *Allium sativum* (8) | *Crescentia cujete*[c] |
| *Rosa chinensis* (6) | | *Crescentia cujete*[c] (8) | |
| *Turnera diffusa* (6) | | *Pinus oocarpa* (8) | |
| | | *Punica granatum* (8) | |
| | | *Cinnamomum zeylanicum*[c] (7) | |
| | | *Crescentia alata*[c] (7) | |
| | | *Gnaphalium roseum*[c] (7) | |
| | | *Cassia grandis*[c] (6) | |
| | | *Citrus* sp.[c] (6) | |
| | | *Mangifera indica* (6) | |
| | | *Piper amalgo* (6) | |

[a]Species mentioned six or more times (for details see text).
[b]Principal species of the Mixe based on Heinrich (1989) (41–43); and includes only taxa documented as important medicinal plants for at least one of the other studies.
[c]Parallel reports of the species (or the genus) with *two* indigenous groups.
[d]Parallel reports of the species (or the genus) with *three* indigenous groups.

The parallel use of plant taxa may be due to:

- coincidence (a random selection of similar species),
- similar criteria for selecting plants (see Heinrich, 1998),
- shared information on the potential usefulness of a plant (i.e. information on the use of a plant is diffused in various regions).

Sharing information is probably responsible for the parallel usage of both *Psidium guajava* and *Chenopodium ambrosioides*, which are known to mestizo groups in Mexico and are widely distributed as fruit tree and common weed, respectively. Whatever the reason for parallel usage, these plants are of particular interest for phytomedical and health care research.

Regarding the category of dermatological diseases, only 1 species (Mexican ''Arnica'' or Mexican ''sunflower'' –*Tithonia diversifolia*) is commonly used by 3 of the 4 groups and is a rarely used medicinal plant with the forth group –the Maya. No species was common to all groups (Table 4). *T. diversifolia* is also known from various regions of Veracruz for treating dermatological conditions (Amo, 1979). It is native to the lowlands of southeastern Mexico and Central America but it is not well known in the ethnobotanical literature (Heinrich, 1996). Although a tall shrub (2–3 m), the plant is often referred to as *arnica* because the conspicuous yellow flower heads resemble the European *Arnica montana*. Bork *et al*. (1996) have shown that the leaf extract acts as a potent inhibitor of an inflammatory transcription factor. The widespread use of this plant in Mexico is presumably due to its pharmacological effect and its superficial similarity to European arnica which European settlers might have used as an explanatory model for using this plant.

Regarding the category of ''respiratory diseases'', again only one plant, bougainvillaea (*Bougainvillaea glabra*) which was introduced from South America, is known to 3 of the 4 groups (Table 5). Although this species is mostly planted as an ornamental, it is widely used to treat respiratory conditions, yet this may not be due to specific pharmacological effects (Weimann and Heinrich, 1997).

The concordance of plant use for the categories of respiratory and dermatological diseases is greatest between the neighbouring Mixe and Zapotecs, while not a single species is shared by the Maya with the other three groups. Noteworthy are the differences in the various categories of indigenous uses. A large proportion of all species listed for gastrointestinal illnesses are shared by at least 2 ethnic groups, however this is not the case for dermatological and respiratory illnesses. A random selection of the same or closely related species cannot account for the observed usage patterns. We can provide only possible explanations for the parallel use or lack thereof. As can be seen in Table 1, the selection criteria of the four groups differ. The hot–cold system is, for example, very important with the Zapotecs, while the classification based on olfactory and taste properties is essential for the Mixe (cf. Frei *et al*., 1998; Heinrich, 1998). The parallel use is therefore presumably not due to the classificatory system. It is thus likely that the diffusion of shared information plays a more important role in gastrointestinal disorders, while the plants chosen to treat conditions of the other 2 categories are locally available. Another noteworthy feature is the importance of cultivated plants (e.g. fruit trees) in the medical system of the four groups (see also Heinrich and Antonio Barrera, 1993). This group of plants seems to be far more likely to be selected than non-cultivated ones.

### *Intracultural informant consensus as criterion for evaluating the role of medicinal plants*

While this analysis yields relevant data on the *intra*cultural and *inter*cultural importance of plants,

Table 6. Comparison of the *individual use-reports* for gastrointestinal illnesses among the Nahua

| Species | DIA/ DYS | STA/ EMP | CRA | ILL DEF | NAU/ VOM | INF/ PAR | LAX | LIV/ GAL | $n_{tot}$ |
|---|---|---|---|---|---|---|---|---|---|
| *Tagetes erecta* | 10[a] | | | | | 1 | | | 11 |
| *Marrubium vulgare* | | | 2 | **6** | 2 | | | | 10 |
| *Ruta chalepensis* | | **10** | | | | | | | 10 |
| *Lippia alba* | **7** | | 2 | | | | | | 9 |
| *Matricaria recutita* | | | | **7** | | | | 1 | 8 |
| *Artemisia ludoviciana* ssp. *mexicana* | 1 | 1 | 2 | | | **3** | | | 7 |
| *Psidium guajava* | 1 | | | 2 | 2 | 1 | | 2 | 7 |
| *Verbena menthaefolia* | 1 | | **5** | | | | | 1 | 7 |
| *Artemisia absinthium* | | | | 5 | | | | 1 | 6 |
| *Baccharis conferta* | **3** | | **3** | | | | | | 6 |
| *Chenopodium ambrosioides* | | | | | | **6** | | | 6 |
| *Erigeron karvinskianus* | 1 | 1 | | **3** | 1 | | | | 6 |
| *Phyla scaberrima* | | | **6** | | | | | | 6 |
| *Rosa chinensis* | | | | 1 | | 1 | **4** | | 6 |
| *Biophytum dendroides* | **5** | | | | | | | | 5 |
| *Foeniculum vulgare* | 1 | 1 | 1 | **2** | | | | | 5 |
| *Ocimum basilicum* | | **4** | | 1 | | | | | 5 |
| *Chrysanthemum parthenium* | | | | **4** | | | | | 4 |
| *Hyptis pectinata* | | | **2** | 1 | 1 | | | | 4 |
| *Justicia spicigera* | | | | **4** | | | | | 4 |
| *Ricinus communis* | | **4** | | | | | | | 4 |
| *Solanum pubigerum* | | 1 | | | | **3** | | | 4 |
| *Baccharis trinervis* | | 1 | | 1 | | | | 1 | 3 |
| *Eupatorium* sp. | | **3** | | | | | | | 3 |
| *Hamelia patens* | | | | **3** | | | | | 3 |
| *Sambucus mexicana* | | | | **3** | | | | | 3 |
| *Oenothera rosea* | | | | **3** | | | | | 3 |

CRA = gastrointestinal cramps/colics, DIA/DYS = diarrhea/dysentery; ILL DEF = ill-defined stomach problems; INF/PAR = gastrointestinal infections/parasites; LAX = used as laxative; LIV/GAL = liver and gall bladder remedies, NAU/VOM = nausea/ vomiting, STA/EMP = stomach ache (unspecified) and *empacho*; $n_{tot}$ total number of use-reports.

[a]Mostly with children.

Bold: ≥40% of the total number of individual use-reports for this species.

the approach may be criticised for *not* taking into account its specific use. The documentation of plant usage in ethnobotanical studies is normally not based on clinical observation. Even if several informants describe a similar use, we know very little about the underlying clinical problems. For example, one informant mentions "air in the stomach" and the other "dysentery", but in both cases, the clinical cause may be amoebiasis. Thus, in effect, we only compare the reports of plant usage given by the healers. Tables 6 and 7 show that, in many cases, plants are used for similar purposes within a category. The data are drawn from the ethnobotanical studies on the Nahua and Maya. They are representative for the other categories of use. Many species are clearly associated with one illness, for which most or all use-reports were documented, e.g. with the Nahua marigold (*Tagetes erecta*) and catmint (*Lippia alba*) for diarrhoea and dysentery, and honey herb (*Phyla scaberrima*) for cramps. Examples for divergent usage are *Baccharis conferta*, used for cases of diarrhoea as well as gastrointestinal cramps, and *Psidium guayava* which is used by the Nahua to treat a diversity of gastrointestinal illnesses. The same is true for the Maya (see Table 7). *Abrus precatorius*, *Manilcara zapota* and *Psidium guayava* are examples of species used by most or all informants for similar conditions.

## CONCLUSION

If the role of medical ethnobotany is to be more than just compiling lists of plants used in indigenous medical systems, a standardised methodology is necessary to enable comparative evaluations. This paper discusses three ethnobotanical studies, in which a similar methodology was used and presents an *inter*cultural comparison. The comparative approach is practical since both consensus and variation can be addressed. While the species used by the 3 indigenous groups vary, the data indicate that there are well-defined criteria specific for each culture which lead to the selection of a plant as a medicinal. These criteria have been discussed elsewhere (Frei *et al.*, 1998; Heinrich, 1998; Weimann and Heinrich, 1998). The specific reasons for selecting a species or groups of species remain to be elucidated, but the data presented in the tables show that the healers do not select plants for medicinal use at random, but rely instead on a limited set of herbal resources (cf. Moerman, 1996). In selecting such resources people in a culture may rely on the sensory perception of the environment and/or on more abstract forms of understanding (e.g. the hot–cold concept or the idea of *similia similibus curantur*). In a recent series of papers we have focused specifically on the role of chemosensory perception as com-

Table 7. Comparison of the *individual use-reports* for gastrointestinal illnesses among the Maya

| Species | DIA/ DYS | NAU/ VOM | OJO | STA/ CRA | AIR/ IND | INF/ PAR | CIR/ GAS | $n_{tot}$ |
|---|---|---|---|---|---|---|---|---|
| *Mentha* aff. *piperita* | 4 | **13** | | 6 | 1 | 3 | | 27 |
| *Chenopodium ambrosioides* | 1 | 4 | | 5 | | 6 | | 16 |
| *Mentha* aff. *citrata* | 3 | **7** | | 6 | | | | 16 |
| *Aristolochia maxima* | 5 | 1 | 1 | 2 | **6** | | | 15 |
| *Lippia stoechadifolia* | 2 | **10** | | | 1 | 1 | | 14 |
| *Dorstenia contrajerva* | 3 | 1 | | 4 | 4 | | 2 | 14 |
| *Abrus precatorius* | | | **12** | 1 | | | | 13 |
| *Artemisia ludoviciana* spp. *mexicana* | 1 | **7** | 1 | 3 | | 1 | | 13 |
| *Callicarpa acuminata* | **6** | 2 | 4 | 1 | | | | 13 |
| *Manilkara zapota* | **11** | | | | | 1 | | 12 |
| *Psidium guajava* | **10** | | 1 | | | | | 11 |
| *Citrus aurantium* | 4 | 2 | 1 | 1 | 1 | 2 | | 11 |
| *Lippia alba* | 1 | **8** | | 2 | | | | 11 |
| *Ruta chalepensis* | 2 | 3 | **5** | | | 1 | | 11 |
| *Citrus sinensis* | 2 | 2 | 1 | 2 | 4 | | | 11 |
| *Zingiber officinale* | 1 | | | 2 | **7** | | 1 | 11 |
| *Ocimum micranthum* | **6** | 4 | 1 | | | | | 11 |
| *Cissampelos pareira* | | | **9** | | | | | 9 |
| *Malvaviscus arboreus* | **8** | | | | | 1 | | 9 |
| *Bidens squarrosa* | | 1 | **8** | | | | | 9 |
| *Cissus trifoliata* | | | **8** | | | | | 8 |
| *Triumfetta semitriloba* | **8** | | | | | | | 8 |
| *Mentha* aff. *arvensis* | | | | **4** | | **4** | | 8 |
| *Punica granatum* | **6** | | | | | 1 | | 7 |
| *Hylocereus undatus* | **6** | | | | | 1 | | 7 |
| *Microgramma nitida* | | | | 1 | | 1 | **5** | 7 |
| *Citrus* aff. *aurantifolia* | 1 | 1 | 2 | | 1 | 1 | | 6 |
| *Piscidia piscipula* | 2 | 1 | 2 | 1 | | | | 6 |

AIR/IND = "*air in the stomach*"/indigestion; CIR/GAS = *cirro*[a]/gastritis; DIA/DYS = diarrhea/dysentery; INF/PAR = gastrointestinal infections/parasites; NAU/VOM = nausea/vomiting; OJO[b] = green diarrhea, mostly with children; STA/CRA = stomach ache, cramps/colics; $n_{tot}$ total number of use-reports.

[a]Organ located behind the navel (Berlin *et al*., 1993).

[b]Mal de ojo: an illness caused by the "strong" look of a person.

Bold: ≥40% of the total number of individual use-reports for this species.

pared to other forms of perceiving and interpreting the environment. There has been little attention paid to the role of culture as a factor affecting the interpretation of chemosensory input. What has been lacking almost entirely is research on the meaning and use of chemosensory information for any populations (Brett and Heinrich, 1998) and consequently on the role this information has in the selection and continued use of medicinal plants. Such analyses –if they are combined with an analysis as the one presented above– will then allow a better understanding of the pharmaco-anthropological basis of medicinal plant use.

An additional advantage of the methodology presented here is that it allows the comparison of the relative importance of medicinal plants in a culture (intracultural evaluation). The summing of use reports from selected key informants (e.g. healers) is a simple technique appropriate for fieldwork which is conducted by a single researcher or small research groups.

Since the flora in the 3 regions is rather similar but not identical (Rzedowski, 1978), the comparison presented here shows the importance of managed or cultivated plants (cf. Heinrich and Antonio Barrera, 1993) in the medical system of these Indian groups. Potential medicinal plants are passed on from one area to another because they are perceived to be effective and they are then cultivated close to the house. The importance of cultivated plants is in sharp contrast to the Highland Maya, where almost no cultivation of medicinal plants occurs (J.R. Stepp, pers. comm. 1998).

Gastrointestinal illnesses are the category which yielded the largest number of species used simultaneously by two or more groups. The reasons for this still remain to be elucidated. But it is tempting to speculate that this may at least partially be due to the enormous importance this group of illnesses has in all cultures studied (Heinrich *et al*., 1992). Another reason may be the more frequent exchange of information on such uses as well as seeds or cuttings of the plants. The categories respiratory and dermatological diseases showed very little concordance between the groups. These two groups of resources thus may well be considered to be traditional for the people we worked with.

Informant consensus within a community and between cultural groups indicates which plants are widely used and thus aids in the selection of plants for pharmacological and phytochemical studies. The data presented here also show that the ethnobotanical samples are sufficient and that the important medicinal plant usages were documented in the three regions. This approach does not take into account the relative importance of indigenous phytotherapy as opposed to other forms of indigenous therapy or biomedical forms of treatment. Such a study would require additional information that is beyond the scope of this paper.

While the comparative studies in medical anthropology cited in the introduction discuss complex cultural domains (birth, menopause), this paper presents data on a specific and well-circumscribed phenomenon –the medicinal usage of plants. This approach is a useful methodology for analysing ethnobotanical data in order to get a better understanding of the cultural importance of certain groups of plants *intra-* and *inter*culturally. Such rigorous analyses should be adopted more widely in ethnobotany.

*Acknowledgements*—This research project would not have been possible without the help of many people in the four regions, especially the midwives, healers, and specialists in medicinal plants. These persons are the original keepers of the ethnobotanical knowledge presented here. The botanical identification at the Herbario Nacional (MEXU) was performed in collaboration with numerous specialists of this institution, particularly O. Téllez V., R. Lira S., J. L. Villaseñor R., L. and R. Torres C. as well as Fr. Ramos M. Other identifications were achieved at the Herbarium of the Instituto de Ecología (XAL) in Xalapa, Veracruz and the Centro de Investigación Científica de Yucatán (CICY), Mérida. The collaboration with various Centros Coordinadores of the Instituto Nacional Indigenista is gratefully acknowledged. We are very grateful to Prof. H. Rimpler for supervising the research of C. W. and for his helpful comments, to Dr. John Plant (both Freiburg) and to J. R. Stepp (Athens, GA) for critically revising the manuscript and to Dipl. geogr. Ruedi Haller (Zernetz, CH) for providing the map. Financial support by the SDC (Swiss Agency for Development and Cooperation, Berne, Switzerland) and the SANW (Swiss Academy of Natural Sciences) to A. A. and B. F. is gratefully acknowledged. C. W. thanks the Deutsche Akademische Austauschdienst (Bonn, FRG), the Secretaría de Relaciones Exteriores (México, D.F., México), and the Freiburger Wissenschaftliche Gesellschaft (Freiburg, FRG).

## REFERENCES

Aguilar, A., Camacho, J. R., Chino, S., Jácquez, P. and López, M. E. (1994) Herbario Medicinal del Instituto Mexicano del Seguro Social. Instituto Mexicano del Seguro Social, México, D.F.

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

Amo, R. S. del (1979) Plantas medicinales del Estado de Veracruz. Instituto Nacional de Investigaciones sobre Recursos Bioticos, Xalapa (Veracruz).

Ankli, A., Sticher, O. and Heinrich, M. (n.d.) Medical ethnobotany of the Yucatec Maya: healers' consensus as a quantitative criterion. *Economic Botany*, in press.

Berlin, B. and Berlin, E. A. (1996) *Medical Ethnobiology of the Highland Maya of Chiapas, Mexico*. Princeton University Press, Princeton, NJ.

Berlin, E. A., Jara A., V. M., Berlin, B., Breedlove, D. E., Duncan, T. O. and Laughlin, R. M. (1993) Me'winik: discovery of the biomedical equivalent for a Maya ethnomedical syndrome. *Social Science and Medicine* **37,** 671–678.

Bork, P. M., Schmitz, M. L., Weimann, C., Kist, M. and Heinrich, M. (1996) Nahua Indian medicinal plants (Mexico): inhibitory activity on NF-κB as an anti-inflammatory model and antibacterial effects. *Phytomedicine* **3,** 263–269.

Bork, P. M., Schmitz, M. L., Kuhnt, M., Escher, C. and Heinrich, M. (1997) Pure sesquiterpene lactones and sesquiterpene lactone containing Mexican Indian medicinal plants as potent inhibitors of nuclear factor κB (NF-κB). *FEBS Letters* **402,** 85–90.

Brett, J. and Heinrich, M. (1998) Culture perception and the environment. *Journal of Applied Botany* **72**(3/4), 67–69.

Etkin, N., ed. (1994) *Eating on the Wild Side. The Pharmacologic, Ecologic and Social Implications of Using Noncultigens*. University of Arizona Press, Tucson.

Farnsworth, N. R. (1990) The role of ethnopharmacology in drug development. *Ciba Foundation Symposium*, 154, pp. 2–11. Wiley, Chichester, U.K.

Frei, B., Sticher, O. and Heinrich, M. (1998) Medical ethnobotany of the Zapotecs of the Isthmus-Sierra (Oaxaca, Mexico). *Journal of Ethnophamacology*, **62,** 149–165.

Frei, B., Sticher, O., Viesca Treviño, C. and Heinrich, M. (1998) Plants as medicines and food: Zapotec criteria for selection. *Journal of Applied Botany* **72**(3/4), 82–86.

Friedman, J., Yaniv, Z., Dafni, A. and Dalewitch, D. (1986) A preliminary classification of the healing potential of medicinal plants, based on a rational analysis of an ethnopharmacological field survey among Bedouins in the Negev Desert, Israel. *Journal of Ethnopharmacology* **16,** 275–287.

Harris, M. (1968) *The Rise of Anthropological Theory*. Thomas Y. Crowell, New York.

Heinrich, M. (1989) Ethnobotanik der Tieflandmixe (Oaxaca, Mexico) und phytochemische Untersuchung von *Capraria biflora* L. (Scrophulariaceae). Dissertationes Botanicae No. 144. J. Cramer in Gebr. Borntraeger Verlagsbuchhandlung, Berlin und Stuttgart.

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

Heinrich, M. (1996) Ethnobotany of Mexican compositae: an analysis of historical and modern sources. In *Proceedings of the International Compositae Conference*, Kew, 1994, Biology and Utilization Editor in Chief D. J. N. Hind, vol. eds. P. D. S. Caligaria and D. J. N. Hind, Vol. 2, pp. 475–503. Royal Botanic Gardens, Kew.

Heinrich, M. (1998) Indigenous concepts of medicinal plants in Oaxaca, Mexico: Lowland Mixe plant classification based on organoleptic characteristics. *Journal of Applied Botany* **7**(1/2), 75–81.

Heinrich, M. and Antonio Barrera, N. (1993) Medicinal plants in a Lowland Mixe Indian community (Oaxaca, Mexico): management of important resources. *Angewandte Botanik* **67,** 141–144.

Heinrich, M., Rimpler, H. and Antonio Barrera, N. (1992) Indigenous phytotherapy of gastrointestinal disorders in a Mixe Lowland community. *Journal of Ethnopharmacology* **36,** 63–80.

Hör, M., Rimpler, H. and Heinrich, M. (1995) Inhibition of intestinal chloride secretion by proanthocyanidins from *Guazuma ulmifolia*. *Planta Medica* **61,** 208–212.

Johns, T., Kokwar, J. O. and Kimanani, E. K. (1990) Herbal remedies of Luo of Siaya District, Kenya: establishing quantititave criteria for consensus. *Economic Botany* **44,** 369–381.

Jordan, B. (1979) *Birth in Four Cultures*. Eden Press, Montreal.

Kato, T., Frei, B., Heinrich, M. and Sticher, O. (1996) Antibacterial hydroperoxysterols from *Xanthosoma robustum*. *Phytochemistry* **41,** 1191–1195.

Lipp, F. (1991) *The Mixe of Oaxaca. Religion, Ritual and Healing*. University of Texas Press, Austin.

Lock, M. (1993) *Encounters with Aging: Mythologies of Menopause in Japan and North America*. University of California Press, Berkeley.

Moerman, D. E. (1996) An analysis of the food plants and drug plants of Native North America. *Journal of Ethnopharmacology* **52,** 1–22.

Morton, J. F. (1981) *Atlas of Medicinal Plants of Middle America, Bahamas to Yucatan*. C. Thomas, Springfield, IL.

Ngokwey, N. (1995) Home remedies and doctor's remedies in Feira (Brazil). *Social Science and Medicine* **40,** 1141–1153.

Phillips, O. L. (1996) Some quantitative methods for analyzing ethnobotanical knowledge. In *Selected Guidelines for Ethnobotanical Research*. A Field Manual. Advances in Economic Botany 10, 171–197, ed. M. N. Alexiades. New York Botanical Garden, New York.

Phillips, O., Gentry, A. H., Reynel, C., Wilkin, P. and Gálvez-Durand, C. (1994) Quantitative ethnobotany and Amazonian conservation. *Conservation Biology* **8,** 225–248.

Redfield, R. and Villa Rojas, A. (1934) Chan Kom: a Maya village. Publication No. 348, Carnegie Institute of Washington, Washington DC.

Rzedowski, J. (1978) *Vegetación de México*. Editorial Limusa, México, D.F.

Trotter, R. (1981) Remedios caseros: Mexican–American home remedies and community health problems. *Social Science and Medicine* **15B,** 107–114.

Trotter, R. and Logan, M. (1986) Informant consensus: a new approach for identifying potentially effective medicinal plants. In *Plants in Indigenous Medicine and Diet: Biobehavioural Approaches*, ed. Nina L. Etkin, pp. 91–112. Redgrave Publishers, Bedford Hills, NY.

Weimann, C. and Heinrich, M. (1997) Indigenous medicinal plants in Mexico: the example of the Nahua (Sierra de Zonglicia). *Botanica Acta* **110,** 62–72.

Weimann, C. and Heinrich, M. (1998) Concepts of medicinal plants among the Nahua of the Sierra de Zongolica, Veracruz (Mexico). *Journal of Applied Botany*, **72**(3/4), 87–91.

Weitlaner Johnson, I. and Weitlaner, R. J. (1963) Nuevas versiones sobre calendarios Mijes. *Revista Mexicana de Estudios Antropologicos* **19,** 41–62.