Medicinal Flora of the Popoluca, Mexico: A Botanical Systematical Perspective

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Leonti, Marco *(Department of Applied BioSciences, Institute of Pharmaceutical Sciences, Swiss Federal Institute of Technology (ETH) Zurich, Winterthurerstr. 190, CH-8057 Zürich, Switzerland),* **Fernando Ramirez R.** *(Proyecto Sierra de Santa Marta, A.C. Cuauhtémoc 10, Centro Histórico, Xalapa 91000, Veracruz, México),* **Otto Sticher** *(Department of Applied BioSciences, Institute of Pharmaceutical Sciences, Swiss Federal Institute of Technology (ETH) Zurich, Winterthurerstr. 190, CH-8057 Zürich, Switzerland), and* **Michael Heinrich** *(Centre for Pharmacognosy and Phytotherapy, The School of Pharmacy, University of London, 29—39 Brunswick Sq. London, WC1N 1AX, UK; e-mail: phyto@ulsop.ac.uk).* Medicinal Flora of the Popoluca, Mexico: A Botanical Systematical Perspective. *Economic Botany 57(2):218–230, 2003. We studied the medicinal plants used by the Popoluca of the Sierra de Santa Marta (eastern Mexico). Using Moerman's method of regression analysis we determined which ethnomedically used taxa are over-represented in the Popolucan pharmacopoeia (e.g., Asteraceae) and which are underrepresented (e.g., Orchidaceae). Moerman et al. (1999) found high correlation between the holarctic pharmacopoeias and assumed that apart from the relatedness of the northern floras a "global pattern of human knowledge" may account for this finding. Although the Popoluca dwell in a habitat dominated by a neotropical flora but intermixed with important holarctic elements, they include considerably fewer neotropical taxa in their pharmacopoeia as one would expect if the historical transmitted knowledge were influencing their selection. This finding confirms the theory stated by Moerman et al. However, the Popoluca include some neotropical taxa in their pharmacopoeia and thus a moderate correlation exists between the Popolucan pharmacopoeia and the neotropical pharmacopoeia analysed by Moerman et al. We therefore conclude that apart from historically transmitted knowledge about specific taxa the "global pattern of human knowledge" addressed by Moerman et al. is largely based on "common selection criteria."*

Estudiamos las plantas medicinales que usan los Popolucas de la Sierra de Santa Marta, Veracruz, en el oriente de México. Aplicando el método de análisis de regresión de Moerman, determinamos cuales taxa utilizados etnomédicamente están sobre-representados (p. ej. Asteraceae) y cuáles taxa están sub-representados (p. ej. Orchidaceae) en la farmacopea Popoluca. Moerman y colaboradores encontraron una alta correlación entre diversas farmacopeas holárticas y suponen que este hecho se debe a la semejanza de las floras boreales y a la existencia de un "cuadro común de sabiduría humana." Los Popolucas, quienes viven en un medio ambiente dominado por la flora neotropical mezclada con elementos boreales, incluyen menos taxa neotropicales en su farmacopea de lo que se hubiera esperado. Este resultado apoya la teoría expresado por Moerman et al. sobre la influencia de un conocimiento de la etnofarmacopea holártica que ha sido transmitido desde tiempos prehistóricos. Sin embargo comprobamos que existe una clara influencia neotropical en la farmacopea Popoluca por lo cual concluimos que además de los conocimientos sobre taxa específicos transmitidos históricamente, el hipotético "patrón común de sabiduría humana" citado por Moerman et al. se refiere también a "criterios comunes de selección."

Während einer ethnobotanischen Feldstudie untersuchten wir die Medizinalpflanzen der Popoluca in der Sierra de Santa Marta (östliches Mexiko). Wir wandten Moermans Methode der Regressionsanalyse an, um die ethnomedizinisch überrepräsentierten (z. B. Asteraceae) und unterrepräsentierten Taxa (z. B. Orchidaceae) dieser Ethnopharmakopöe zu bestimmen. Moerman et al., welche eine hohe Korrelation zwischen holarktischen Pharmakopöen fanden, vermuten, dass neben der Verwandschaft der nördlichen Flora ein "globales Muster menschlichen Wissens" für dieses Ergebnis verantwortlich ist. Die Popoluca, welche in einem Habitat siedeln,

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in dem die neotropische Flora dominiert, aber klare holarktische Einflüsse aufweist, schliessen bedeutend weniger neotropische Elemente in ihre Pharmakopöe mit ein, als man erwarten würde, wenn nicht historisch tradiertes Wissen ihre Selektion beeinflussen würde. Dieses Ergebnis bestätigt die Theorie von Moerman et al. Da jedoch in der Pharmakopöe der Popoluca ein bestimmter Teil der neotropischen Flora vertreten ist, besteht eine moderate Korrelation zu der von Moerman et al. analysierten neotropischen Pharmakopöe. Daher schlussfolgern wir, dass das von Moerman et al. vermutete "globale Muster menschlichen Wissens" nebst historisch tradiertem phytomedizinischem Wissen über spezifische Taxa vor allem auch auf "gemeinsamen Selektionskriterien" beruht.

Key Words: traditional medicine; ethnobotany; ethnopharmacy; Isthmus of Tehuantepec; Macro-Mayan; medicinal plant selection; Mexico; Popoluca; regression analysis.

Research on medicinal and other useful plants used in indigenous societies has been driven by two complementary interests: The use of such information for research in the field of the natural sciences, especially with regard to 'new' bioactive natural products derived from plants and the use of plant extracts in primary health care (Heinrich and Gibbons 2001) and the interest in better understanding the anthropological basis, if possible on a cross-cultural basis, of the use of these resources by humans and particularly on the rationale(s) behind the selection of these resources (Moerman et al. 1999).

One particularly exciting development which contributes to both lines of investigation is the study of botanical systematic aspects of plant usage. Dan Moerman and his colleagues (e.g., 1996, 1998a,b) have developed and used (partially in collaboration with several other scholars) a method which allows for a statistical analysis of ethnobotanical information based on that the number of medically used plant taxa and the total number of taxa in a certain region is known.

Most of their research focused on the North temperate region of North America, but also on three additional northern (Kashmir, Korea, Chiapas) and one southern (Ecuador) hemispheric ethnopharmacopoeias. Only one neotropical lowland region (upper Napo River valley, Ecuador) is included in his analyses. The main reason for this is a lack of taxonomic and systematic research in such regions. The results of the comparison by Moerman et al. (1999) show that holarctic peoples rely on similar plant families in their health care. The Pearson correlation factors between the holarctic data sets are higher than 0.6 while the correlation of the Ecuador data set with the holarctic data set is lower than 0.19 (maximum possible correlation is one, lowest is zero). Moerman et al. (1999) suggest that the relatively high correlation between the holarctic ethnopharmacopoeias and the low correlation between the holarctic pharmacopoeias and the neotropical one is due to the relatedness of the northern floras and the possibility that the knowledge about medicinal plants has been passed on from prehistoric times through space and time. This implies that the peoples entering the New World through the Beringian Street already shared a common knowledge about medicinal plants with the peoples migrating to other areas and remaining on the Asiatic continent.

There is a widespread acceptance that North America was first settled at least around 15 000 yr B.P., but some authors postulate a date as early as 40,000 yr B.P. (Layrisse and Wilbert 1999). According to these authors, three major waves of immigrants populated the Americas. The first wave was of Pre-Mongoloid tribes at around 40 000 yr B.P., followed by Paleo-Mongoloids at 30 000 yr B.P., and the Diego-allele positive Neo-Mongoloids at about 9000 yr B.P. (Layrisse and Wilbert 1999). When peoples crossed the border of the holarctic flora into the realm of the neotropical plant kingdom they were suddenly confronted with plant families that were new to them and had to adapt themselves and their pharmacopoeia to this new pool of plants.

We have recently completed a detailed study of the medicinal plant use of the Popoluca in southern Veracruz, Mexico (Leonti et al. 2001). The Popoluca inhabit the Sierra de Santa Marta, a range of volcanoes between the Lake of Catemaco and the Gulf coast. These volcanoes form the southern foothills of the "Sierra de Los Tuxtlas" mountain range, a region particularly well known for its biodiversity, where the holarctic and neotropical floristic kingdoms overlap. The neotropical influence is stronger than the holarctic one. According to Rzedowski (1991) the overwhelming part of the Mexican flora belongs to the neotropical plant kingdom, even though the pine and oak forests of the Mexican highlands and Chiapas share the northern and southern floral influences in about equal parts. Important vegetation zones in the Sierra de Santa Marta include the tropical montane cloud forest, the tropical rain forest, and the semi-dry oak forest.

The study area of about 1350 km^2 lies at altitudes between sea level and 1720 m. Ramírez-Ramírez (1999) published a comprehensive checklist of the flora of the region with records for 2400 species. Although, it was estimated that about 3000 species of flowering plants grow in the Sierra (Chevalier and Buckles 1995:182), we consider an evaluation as feasible based on Ramírez-Ramírez's work. This enables an analysis of the use of plants for medical purposes by this indigenous group, which is particularly interesting because the unique composition of the flora including elements from two kingdoms.

Here we report on a regression analysis of the medicinal plants. In order to better understand the cultural rational for the ranking of the most salient plant families we analyse for which categories of illness the respective plant families are used for, elucidate the phytochemical spectra of these families, and highlight ecological and organoleptical characteristics.

Methods

Ethnobotanical Research

The ethnobotanical research was undertaken in the municipalities (municipios) of Hueyapan de Ocampo and Soteapan, southern Veracruz, from March 1999 to July 2000. Fieldwork focused on collecting information on medicinal plant use and general ethnographic data. Dried herbarium specimens and samples for further phytochemical analysis (for details see Leonti et al. 2001; Leonti, Sticher, and Heinrich 2002; cf. Ankli, Sticher, and Heinrich 1999) were also collected.

The research was performed with permit No. DOO. 02.-1750, obtained from the Instituto Nacional de Ecología, of the Secretaría de Medio Ambiente Recursos Naturales y Pesca (SEMARNAP), México. Complete sets of voucher specimens (*Leonti 1-599*) are deposited at the National Mexican Herbarium MEXU (Universidad Nacional Autónoma de México, México, D.F.), the Herbarium-Hortorium of the Colegio de Postgraduados de Chapingo CHAPA (Texcoco), IMSS-M (Instituto Mexicano del Seguro Social, México, D.F.), Instituto de Ecología XAL (Xalapa), the Centre for Pharmacognosy and Phytotherapy, The School of Pharmacy, Univ. London, and the ETH Zurich (CH). Identification was largely conducted at MEXU and the Colegio de Postgraduados en Ciencias Agrícolas, Montecillo, Mexico, but with the help of specialists from these institutions. In this contribution, voucher specimens are only cited if they have not been reported previously in our other publications (Leonti et al. 2001, 2002).

Evaluation Methods

In order to determine the importance of the medicinal plant families, we used Moerman's (1991) method applying regression analysis (Fig. 1). The families were then ranked according to their decreasing residuals (Appendix I), which reflects the proportion of plants used as medicinals in a certain family. The residual is the difference between the number of medicinal species predicted by the regression analysis and the true, ethnographically determined number of medicinal species (Moerman et al. 1999).

Since Moerman and his colleagues used only angiosperm families in his analysis, we decided to do so as well, in order to secure the comparability of the set of data. For the same reason some plant families had to be combined: Anthericaceae and Amaryllidaceae into Liliaceae s.l.; Phyllonomaceae into Grossulariaceae; Hypericaceae into Clusiaceae; Mimosaceae, Fabaceae s.str. and Caesalpiniaceae into Fabaceae s.l.

To determine the relationship between the different floras the Pearson correlation coefficient of the number of species per family was calculated. Similarly, the relationship of the different medicinal floras was calculated by the Pearson correlation coefficient of the residuals (Moerman et al. 1999).

Results and Discussion

The medicinal flora of the Popoluca consists of 614 plant species, contributed by 72 informants, with a total of 4488 use-reports (Leonti et al. 2001). The plants belong to 117 of the 174 Angiosperm families recorded for the region (Ramírez-Ramírez 1999). According to the residuals of the regression analysis ($y = 0.2716x$

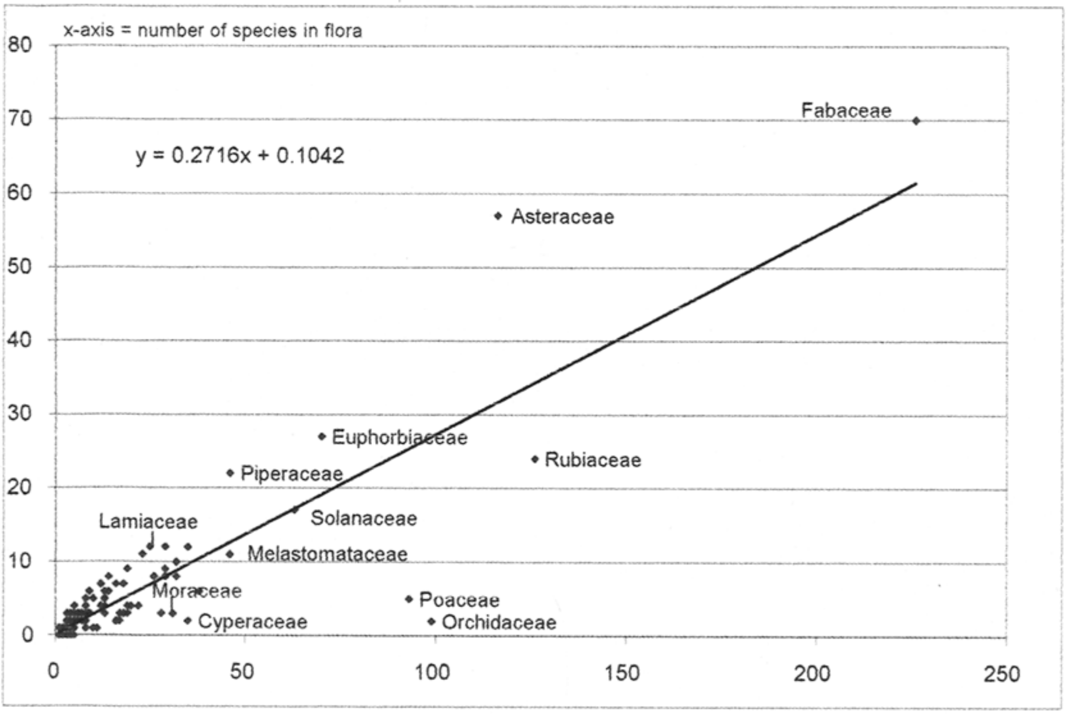

Fig. 1. Regression analysis of the medicinal flora of the Popoluca. X axis, number of species per family in the flora; Y axis, number of medicinal plants per family.

+ 0.1042) of the Popolucan ethnomedical flora the top five families used by the Popoluca are (Table 1): Asteraceae, Piperaceae, Fabaceae, s.l., Euphorbiaceae, and Lamiaceae. The five families (positions 170–174, Table 2) with the lowest level of usage in the regression analysis are Orchidaceae, Poaceae, Rubiaceae, Cyperaceae, and Moraceae.

It is of considerable ethnobotanical interest to understand the cultural reasons for a taxon's usage or its avoidance. Reasons for a taxon's ethnomedical importance include, for example:

1) Ecological factors, including the importance of some of the taxa as managed house garden plants. If a high percentage of medicinal plants from a certain plant taxon (e.g., Lamiaceae) is cultivated in home gardens, many species may well be of particular ethnomedical importance, and have further ethnobotanical uses (culinary, ornamental, or for construction). Very often such species are hard to find in the natural habitat or are introduced into the region. It is important to note that if the calculation of the regression

TABLE 1. RANKING OF THE FIVE MOST USED PLANT FAMILIES IN VERACRUZ AS COMPARED TO THE DATASET FROM MOERMAN ET AL. (1999).

Family	Veracruz	Chiapas[1]	Kashmir[1]	North America[1]	Korea[1]	Ecuador[1]
Asteraceae	1	1	1	1	3	45
Piperaceae	2	105	—	237	89	27
Fabaceae s.l.	3	138	85	253	8	2
Euphorbiaceae	4	21	2	234	13	90
Lamiaceae	5	2	4	8	4	91
Total families	174	144	100	255	136	118

[1] From Moerman et al. 1999.

TABLE 2. RANKING OF THE FIVE LEAST USED PLANT FAMILIES FROM VERACRUZ AS COMPARED TO THE DATASET FROM MOERMAN ET AL. (1999).

Family	Veracruz	Chiapas[1]	Kashmir[1]	North America[1]	Korea[1]	Ecuador[1]
Orchidaceae	174	143	100	245	134	118
Poaceae	173	144	100	255	135	51
Rubiaceae	172	82	9	250	65	109
Cyperaceae	171	142	94	254	136	102
Moraceae	170	113	8	33	21	117
Total families	174	144	100	255	136	118

[1] Data from Moerman et al. 1999.

analysis would have been performed without the introduced species the Lamiaceae would rank 34th and be substituted by the Acanthaceae,

2) Phytochemical characteristics of the plant families relating to the presence of pharmacologically active secondary metabolites,
3) Organoleptical characteristics of the members of a family, e.g., aromatic species are very prominent in the Lamiaceae (Leonti et al. 2002).

In the following the five top and bottom ranked families are discussed separately.

TOP RANKED FAMILIES

Asteraceae. The Asteraceae are the Popoluca's most frequently used family, and take priority in the treatment of illness groups of gastrointestinal disorders, dermatological ailments, skeleto-muscular problems, respiratory ailments and are very important (2nd most often used family) in gynaecology (see Table 3). The Asteraceae are phytochemically very diverse and so far at least 7000 natural compounds have been isolated from chemical classes such as sesquiterpene lactones, diterpenes, phenols, and polyenes (Frohne and Jensen 1998). This variety of chemical compounds has been recorded to have a multitude of pharmacological activities including anti-inflammatory, cytotoxic, bactericidal, fungicidal, and appetite-inducing properties. The pharmacological properties of the compound classes reflect the broad therapeutic application with the Popoluca and may in part explain the Popoluca's reliance on the Asteraceae.

Of the 57 Asteraceae species used seven (12%, *Tagetes* spp., *Artemisia ludoviciana* Nutt., *Porophyllum ruderale* (Jacq.) Cass., *Leonti 224*) are regularly grown in the home gardens for medicinal purposes. They are mainly introduced species and do not occur spontaneously. The rest of the Asteraceae used by the Popoluca are all weeds and normally gathered in the immediate vicinity of the community.

Asteraceae flower heads are attractive and conspicuous. Although there are many species with similarly looking yellow flower heads, and hence are difficult to distinguish. Therefore in folk taxonomy some species are consolidated into one taxon.

Piperaceae. The Piperaceae are predominantly used to treat dermatological complaints (*Piper* spp., *Pothomorphe* sp.) and skeleto-muscular problems (*Peperomia* spp.) such as rheumatic conditions. The Piperaceae are rich in monoterpenes, sesquiterpenes, phenylpropanes and amides, with a variety of significant pharmacological effects recorded (Frohne and Jensen 1998). Out of the 22 medicinal species only *Piper auritum* Kunth is cultivated regularly in home gardens, mainly for culinary reasons to flavour chicken soup, pork stew and pork tamales with its leaves. The main constituent of *P. auritum* leaves is the carcinogenic safrole and thus may constitute a health risk if consumed excessively.

The genus *Piper* and the genus *Peperomia* are morphologically homogeneous and therefore the species are difficult to separate from each other. In Popoluca folk taxonomy all species from the genus *Piper* except *P. auritum* (Acuyo) are called 'Tooso' and are conceived as having more or less the same virtue. Therefore, the high ranking according to the residual of the Piperaceae seems to be largely due to the family's typical characteristics in combination with the inseparability of many of the highly diverse Piperaceae (according to Popoluca concepts) and the Popoluca's indiscriminate use of these species.

Fabaceae, s.l. The Fabaceae, s.l. are most im-

TABLE 3. MOST COMMONLY USED SPECIES IN THE MAJOR GROUPS OF INDIGENOUS USE.

Group of medical use	No. Taxa	First	2nd	3rd	4th	5th
Dermatology	303	Asteraceae	Fabaceae, s.l.	Rubiaceae	Piperaceae	Euphorbiaceae
Gastrointestinal disorders	251	Asteraceae	Fabaceae, s.l.	Myrtaceae	Lauraceae	Euphorbiaceae/Lamiaceae
Gynaecology	218	Fabaceae, s.l.	Asteraceae	Rubiaceae	Lauraceae	Commelinaceae
Urological problems	157	Fabaceae, s.l.	Zingiberaceae	Euphorbiaceae	Malphighiaceae	Araceae
Venomous animals	121	Fabaceae, s.l.	Aristolochiaceae	Cochlospermaceae	Rubiaceae	Piperaceae
Culture bound syndromes	127	Euphorbiaceae	Lamiaceae	Fabaceae, s.l.	Asteraceae	Rubiaceae
Fever and headache	112	Fabaceae, s.l.	Burseraceae	Anacardiaceae	Acanthaceae	Verbenaceae
Skeleto-muscular disorders	101	Asteraceae	Piperaceae	Meliaceae	Fabaceae, s.l.	Solanaceae/Lauraceae
Respiratory complaints	79	Asteraceae	Fabaceae, s.l.	Malvaceae	Myrtaceae	Verbenaceae

portant in the illness categories of gynecology, fever and headache, urological conditions, bites from venomous animals, and are the second most important family to treat gastrointestinal and dermatological complaints. Members of the Fabaceae, s.l. are often rich in polyphenoles (tannins and flavonoids) and triterpene saponins (Frohne and Jensen 1998). Especially the Fabaceae *s.str.* contain many toxic genera and species such as *Canavalia* (lectines), *Ormosia* (chinolizidine alkaloids), *Erythrina* spp. (isochinoline alkaloids), *Crotalaria sagittalis* L. (pyrrolizidine alkaloids). The seeds of *Mucuna pruriens* (L.) DC., containing L-DOPA and hallucinogenic tryptamines, are ground, toasted and used as a coffee surrogate which is typical of rural regions in Guatemala and Mexico (Buckles, Triomphe, and Sain 1998).

Of the 70 medicinally used Fabaceae s.str. twelve (17%) are cultivated regularly in home gardens, ten of these are trees, having ornamental uses (*Caesalpinia pulcherrima* (L.) Sw., *Leonti 118, Senna multijuga* ssp. *doylei* (Britton & Rose) H. S. Irwin & Barneby, *Leonti 70*) or nutritional uses (*Tamarindus indica* L., *Dialium guianense* (Aubl.) Sandwith, *Leonti 298*). *Crotalaria longirostrata* Hook & Arn. (*Leonti 479*) is cultivated and eaten as a vegetable but no soporific (sleep-inducing) effect, as reported by Morton (1994) was mentioned by the Popoluca informants. The frequent use of Fabaceae, s.l. for medicinal purposes is probably due to the conspicuous character of many of its species, their abundance, the diversity of highly active chemical constituents and notable organoleptical properties (see Leonti, Sticher, and Heinrich 2002).

Euphorbiaceae. The Euphorbiaceae are predominately used in the illness categories of gastrointestinal disorders, dermatological complaints, and urological ailments. Polyphenoles (flavonoids and condensed tannins), rubber, different types of alkaloids, cyanogenic glycosides and diterpenes are the main classes of secondary natural products of the Euphorbiaceae (Frohne and Jensen 1998). The genus *Croton,* known to contain toxic diterpene esters, is represented with five species in the Popolucan pharmacopoeia.

Of the 26 medicinal species of Euphorbiaceae, two are cultivated frequently, *Cnidoscolus chayamansa* McVaugh (*Leonti 182*) being primarily used as a vegetable. The Euphorbiaceae have very inconspicuous flowers or inflorescences but the genera are visually distinct on the basis of morphological characters (herbs, shrubs, trees) and all grow as weeds in the vicinity of the villages. Taste and smell characteristics may well be important in selecting and recognizing a species.

Lamiaceae. The Lamiaceae are used in gynaecology and to treat gastrointestinal disorders. Essential oils, tannins, bitter diterpenoids, and iridoid glycosides are typical Lamiaceae constituents with antimicrobial, antimycotic, antiviral, anti-inflammatory and choleretic properties (Frohne and Jensen 1998). Of the twelve Lamiaceae in the pharmacopoeia six introduced species, which do not grow spontaneously are regularly cultivated in the home gardens. *Plectranthus amboinicus* (Lour.) Spreng. (*Leonti 253*) is a medicinal plant and is often used as a herb to flavour meat soups. Neither *Rosmarinus officinalis* L, nor *Ocimum basilicum* L., and *O. micranthum* Willd. (*Leonti 54*) are used in the kitchen.

Least Used Families

Orchidaceae. The pseudobulbs of this family are best known for their starch and glucomannane mucilage. The presence of a variety of alkaloids such as pyrrolizidine and phenylisochinoline alkaloids has been reported (Frohne and Jensen 1998). The Orchidaceae are not important in any of the illness groups; only two out of 99 species are medicinals. The mucilage of *Maxillaria tenuifolia* Lindl. (*Leonti 504*) is used as natural glue in the construction of 'jaranas,' (traditional little guitars). The Orchidaceae are often rare, have relatively scattered distributions and often inaccessible populations, which complicates the acquisition of plant material. Also, in the region of the Popoluca, the orchids do not grow as weeds in the secondary vegetation zones around the villages (Stepp and Moerman 2001).

Poaceae. Silicate is the main chemical characteristic of this family. Normally, low concentrations of coumarine derivatives and cyanogenic glycosides are common (Frohne and Jensen 1998). *Zea mays* L., maize, is the most widely cultivated food plant in the region and in Mexico, in general, but is used medicinally only very rarely by the Popoluca. In the Popolucan pharmacopoeia the genus *Lasiacis* is used for a special dermatological condition, but, as a whole, the Poaceae are important in none of the illness groups. Out of 93 species, five are medicinal and two of these are introduced species cultivated in house gardens: Bamboo, *Bambusa* sp., apart from its medicinal usage is primarily used for construction, and *Cymbopogon* sp., rich in essential oils such as citronellal and geraniol, is used to treat gastrointestinal complaints.

While this family is abundant throughout the region and includes many weeds, the species are normally very inconspicuous and difficult to distinguish, especially in the sterile state. This makes them unlikely candidates to be selected as a medicine.

Rubiaceae. Characteristic of this family are xanthine derivatives, anthranoides, coumarines, triterpenes, triterpene saponines, proanthocyanidines, and indol- and emetane alkaloids (Frohne and Jensen 1998). In the illness categories dermatological conditions and gynecology, the Rubiaceae are the third most frequently used family and therefore of considerable importance in the Popoluca pharmacopoeia. *Coffea arabica* L., coffee, is cultivated as a cash crop in the higher regions and rarely used as a source of medicine. Of the 26 medicinally used species two are regularly grown in home gardens. *Sickingia mexicana* Bullock (*Leonti 272*) used in gynaecology has become a rare species in the past years due to deforestation. Recently, midwives began to cultivate this tree, simultaneously securing their medicine and contributing to the protection of biodiversity. *Gardenia* sp. is mainly grown for ornamental reasons but also has medicinal uses. Some species of the Rubiaceae are utilised extensively by the Popoluca, e.g., *Hamelia patens* Jacq. used for bleeding wounds, which is the species with the second largest number of use reports in the whole ethnopharmacopoeia (Leonti et al. 2001) but the fact that the family is represented by many species, of which a overwhelming majority grows in primary forest remote from the Popoluca villages results in a relatively low ranking. Also the Rubiaceae are (especially in the sterile state) very inconspicuous (*Psychotria* spp.), which probably influences the selection of species from this family.

Cyperaceae. The Cyperaceae have a similar chemical spectrum as the Poaceae. Silicate, proanthocyanidine and essential oils are the

TABLE 4. PEARSON CORRELATION.

Veracruz	Chiapas	Kashmir	North America	Korea	Ecuador
Pearson correl. floras	0.94	0.74	0.68	0.51	0.83
Pearson correl. med. used families	0.81	0.62	0.57	0.54	0.36

main chemical constituents (Frohne and Jensen 1998). Only two out of 35 Cyperaceae species of this region have medicinal uses but are without importance in the pharmacopoeia of the Popoluca. Again, the lack of usage of this taxon seems to be due to the inconspicuous nature of the species. Also, Cyperaceae generally grow in humid and inaccessible habitats.

Moraceae. Very characteristic is the latex which often contains phototoxic furanocumarines and toxic cardenolides (Frohne and Jensen 1998). The Moraceae have no importance in the Popoluca's health care. Out of the 31 species, three are used medicinally. *Ficus pertusa* L.f. (*Leonti 63*) is sometimes grown in house yards as a medicinal plant and as a fruit tree. The neglecting of the Moraceae may in part be explained by their life form as climbers (*Ficus* sp.) which does not allow one to distinguish the species even on the basis of their leaves. Also many taxa are abundant in more or less undisturbed forest habitats.

INTRACULTURAL ETHNOPHARMACOLOGICAL COMPARISON

Chemical characteristics seem to be an essential criterion for plant selection. These are perceived by the Popoluca on the basis of the plant's taste and smell properties and their pharmacological effects. They are essential for selection and continued use of certain taxa as medicine. The high diversity of secondary compounds, taste and smell properties, but also the distinctive plant morphology clearly separates the Asteraceae, the Lamiaceae and the Fabaceae, s.l. organoleptically from the lesser used families such as the Poaceae and the Cyperaceae. Families with many weedy taxa or ones often cultivated in the home gardens are particularly prominent in the pharmacopoeia. The lesser used families, best exemplified by the Orchidaceae, exemplify problems in gathering material of a plant that makes them unlikely candidates for medicinal plants. Both, the Poaceae and Cyperaceae seem to be neglected because they lack conspicuous characteristics which allow an easy distinction among various species. With the Piperaceae and the Euphorbiaceae, on the one hand, and the Rubiaceae and the Moraceae, on the other hand, the differences are not as prominent but point in the same direction.

INTERCULTURAL COMPARISON WITH OTHER REGRESSION ANALYSES

The Asteraceae and the Lamiaceae are generally ranked highly in holarctic ethnopharmacopoeias (Moerman et al. 1999). This points to the holarctic character of the Popolucan pharmacopoeia, while the Piperaceae reflect the neotropical influence in the pharmacopoeia. The Fabaceae's (s.l.) high ranking with the Popoluca, is difficult to analyse (Table 1). They are ranked very low in North American (253rd of 255), Chiapas (138th of 144), and Kashmir (85th of 100), but are the second most used family in Ecuador, and are ranked 8th in Korea. Probably the Popoluca's reliance on the Fabaceae, s.l. reflects neotropical influence. The Euphorbiaceae are highly ranked in Kashmir (2nd of 100), Korea (13th of 136) and Chiapas (21st of 144), but surprisingly under-represented in North America (234th of 255) and low ranked in the Ecuador (90th of 118) set of data.

Generally, the Poaceae, Cyperaceae and Orchidaceae are very rarely selected (Table 2). The Rubiaceae are ranked 10th in Kashmir but are relatively low ranked in the other sets of data. The Moraceae show a positive residual in North America, Kashmir and Korea, while in Mesoamerica and South America the Moraceae are underrepresented in the medicinal floras (Table 2).

PEARSON CORRELATION FACTOR

Not surprisingly the ethnopharmacopoeia (e) and the flora (f) of the Popoluca (southern Veracruz) show the highest correlation (0.81, e and 0.94, f) with the one of the Tzotzil/Tzeltal from highland Chiapas (Table 4). Both ethnic groups live in an area which harbors plant species from the holarctic as well as from the neotropical plant kingdoms, although the neotropical influence is higher in the flora of Veracruz. The most prominent difference is that the Popoluca dwell in the lowland and the Tzotzil/Tzeltal in the highlands. Both groups are part of the Macro-Mayan language stock and are culturally related. The cultural separation may have occurred about 2500 years ago. The high correlation of their pharmacopoeias probably reflects both the biological relatedness of the area and the common cultural past of the two groups. If we compare the relatedness of the flora of the Populuca and the medicinal flora selected by them with other floras/medical floras (Table 4) an analysis using the Pearson correlation indicates the relatedness of the Popolucan (Veracruzian) ethnopharmacopoeia with the others. The only exception is the data for Ecuador. The flora of Veracruz shows a correlation of 0.83 with Ecuador which would predict a correlation of their pharmacopoeias of about 0.75 if the relatedness of their flora would be the only influencing factor. However, the correlation between the Veracruzian and the Ecuadorian pharmacopoeia falls at the much lower level of 0.36.

The Veracruz (V) and the Chiapas (C) pharmacopoeia perform similarly to the other pharmacopoeias. Both show the highest correlations with Kashmir (0.74 C/0.62 V), second highest with North America (0.73 C/0.57 V), third highest with Korea (0.61 C/0.54 V), and the lowest with Ecuador (0.19 C/0.36 V). The correlation of the Chiapas data set to the other holarctic set of data is always higher as compared to Veracruz. On the other hand the Veracruz correlation to the neotropical (Ecuador) set of data is considerably higher than the one from Chiapas.

Thus, the Pearson correlation factors show that the Veracruz flora is most related to the nearby Chiapas flora but is more related to the Ecuador flora than to any true holarctic flora. Nevertheless, the Pearson correlation factors of the different pharmacopoeias show that the Popoluca pharmacopoeia is generally more related to the holarctic pharmacopoeias but shows a clear neotropical influence.

Dicots Compared to Monocots

The classical, but now controversial, separation of the Angiosperms into Monocots (MC) and Dicots (DC) allows a useful analysis of still another aspect. Overall, the MC seem to be less important as compared to the DC. Again this may well be partly due to the inconspicuousness of many of its plants. The most prominent families of the MC are the Araceae (rank 8), the Commelinaceae (rank 10), and also the Liliaceae (rank 13); the latter two are families with many very showy species. All three families show clear differences in their ethnopharmaceutical uses. We documented 18 of 62 medicinal MC species used for urological problems, with 84 (23.5%) of 357 total MC use reports, while 136 of 535 medicinal DC species have a total of 253 (6.2%) reports in this group (DC—total number of use reports: 4029). The MC are thus more likely to be selected for urological problems.

Out of the 62 medicinal MC species, only two (3.2%) with a total of five (1.4%) use reports are used to treat respiratory ailments, while 73 species of the 535 medicinal DC (13.6%) with 198 (5%) use reports were recorded.

Why should a MC be more suitable to treat urologic conditions and less useful to treat respiratory ailments? The empirical medico-historical experience of an ethnic group is of course an essential basis for this, but at this stage the specific reasons remain speculative. Phytochemical as well as organoleptical differences exist. Concerning the phytochemistry, the MC lack ellagic acid and ellagic tannins, whereas tannins and essential oils, polyterpenes and alkaloids are not common, in general. Steroid saponins occur in MC while the DCs have mostly triterpene-saponins and the mucilage of the MC lacks uronic acid (Frohne and Jensen 1998). Regarding the morphology, the MC distinguish themselves by not showing secondary growth, having a moderate diameter, an un-branched axis, and a watery stem. However, we argue that the different spectra of secondary natural products along with the recorded pharmacological properties are not sufficient to explain the unequal useage of these two groups. Such products are indeed responsible for specific organoleptical properties of a botanical drug, a set of criteria which we have previously shown to be an important selection criterion for medicinal plants with the Popoluca (Leonti et al. 2002) and other groups (Heinrich 1998; Brett and Heinrich 1998). In the classificatory system of the Popoluca and other peoples all these factors—the organoleptical perception of a plant, the morphological and ecological traits, and the characteristics in terms of colour, as well as its smell and taste, are used in combination. In case of the preferential treatment of urological ailments with MC and of the respiratory conditions with DC we consider the organoleptical aspect to be more important than direct pharmacological effects.

CONCLUSION

The fact that the Popoluca dwell in an area where the neotropical and the holarctic plant kingdoms overlap makes an ethnobotanical and a botanical-systematic analysis of special interest. Our study provides additional evidence for the concepts developed by Moerman for the reasons for selecting certain plant taxa as medicines. The ancestors of the Popoluca, dwelling in a zone with neotropical as well as holarctic-flora, could choose to a certain extent from a similar pool of plant families as the holarctic peoples to compile their pharmacopoeia but also have a vast array of neotropical taxa to choose from. The correlation factors show that the Popoluca prefer and neglect plant families to a similar extent as holarctic peoples do. Nonetheless, the Popoluca include neotropical plant families in their pharmacopoeia, without being forced by the prevailing flora to do so. The Piperaceae, which are the most salient difference as compared to a purely holarctic ethnopharmacopoeia are used to treat dermatologic conditions. Dermatologic afflictions are very common in the hot and humid lowlands of the tropics. Indeed, based on the number of taxa used and the use-reports, diseases of the skin form the largest group of illnesses suffered by the Popoluca and is the most important illness category (Leonti et al. 2001). We suggest that the high prevalence and variance of dermal afflictions in correlation with the new climatic conditions led to the incorporation of taxa new to the pharmacopoeia. The process that led to the incorporation of the Piperaceae and other neotropical taxa is based on the cultural selection criteria including taste and smell properties of plants. We recently demonstrated the importance of such concepts in a completely unrelated group the Arbëreshë in northern Lucania (southern Italy, Pieroni et al. 2002) and there too weeds were selected based on several characteristics such as their taste and smell properties, but in the latter case on edibility. Thus, we suggest that the common knowledge as proposed by Moerman et al. (1999) should be understood as a selection based on common organoleptic and other culturally defined criteria (Leonti et al. 2002). The origin of the common selection criteria may be best explained with the similar perceptual appreciation of human beings. We argue that the common knowledge is due to common selection criteria and not to just a common knowledge shared by different cultures.

This research also has implications for other studies focusing on the selection of interesting and relevant ethnomedicinal plant species for phytochemical and pharmacological investigations. Not all plants of an ethnopharmacopoeia fit into the emic classification system. Detecting such outliers and subjecting them to pharmacological studies could result in a higher hit rate for promising phytochemical compounds and would at the same time advance our knowledge about such elements of the indigenous ethnopharmacopoeias and their pharmacological effects.

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APPENDIX: RANKED LIST OF RESIDUALS PER FAMILY INCLUDING THE TOTAL NUMBER OF SPECIES OF THE FLORA OF THE SIERRA DE SANTA MARTA AND THE MEDICINAL PLANTS DOCUMENTED.

Ranking	Plant family	Total species	Medicinal spp.	Residual
1	Asteraceae	116	57	25.4026
2	Piperaceae	46	22	9.4076
3	Fabaceae, s.l.	226	70	8.5376
4	Euphorbiaceae	70	27	7.8916
5	Lamiaceae	25	12	5.1091
6	Acanthaceae	23	11	4.6521
7	Amaranthaceae	14	8	4.0956
8	Araceae	29	12	4.0231
9	Sapindaceae	19	9	3.7381
10	Commelinaceae	12	7	3.6386
11	Anacardiaceae	9	6	3.4531
12	Aristolochiaceae	9	6	3.4531
13	Liliaceae, s.l.	8	5	2.7246
14	Rutaceae	16	7	2.5526
15	Oxalidaceae	5	4	2.5391
16	Malvaceae	35	12	2.3941
17	Sapotaceae	13	6	2.3671
18	Fagaceae	10	5	2.1816
19	Tiliaceae	14	6	2.0956
20	Crassulaceae	3	3	2.0821
21	Cucurbitaceae	18	7	2.0096
22	Chrysobalanaceae	4	3	1.8106
23	Begoniaceae	8	4	1.7246
24	Menispermaceae	8	4	1.7246
25	Phytolaccaceae	5	3	1.5391
26	Rhamnaceae	5	3	1.5391
27	Malpighiaceae	13	5	1.3671
28	Simaroubaceae	6	3	1.2676
29	Verbenaceae	32	10	1.2086
30	Burseraceae	3	2	1.0821
31	Lauraceae	29	9	1.0231
32	Nyctaginaceae	7	3	0.9961
33	Apocynaceae	26	8	0.8376
34	Agavaceae	4	2	0.8106
35	Polygalaceae	4	2	0.8106
36	Rosaceae	4	2	0.8106
37	Smilacaceae	4	2	0.8106
38	Bombacaceae	8	3	0.7246
39	Loranthaceae	8	3	0.7246
40	Marantaceae	8	3	0.7246
41	Zingiberaceae	8	3	0.7246
42	Meliaceae	12	4	0.6836
43	Sterculiaceae	12	4	0.6386
44	Urticaceae	12	4	0.6386
45	Balsaminaceae	1	1	0.6251
46	Basellaceae	1	1	0.6251
47	Bixaceae	1	1	0.6251
48	Caprifoliaceae	1	1	0.6251
49	Chenopodiaceae	1	1	0.6251
50	Cochlospermaceae	1	1	0.6251
51	Cuscutaceae	1	1	0.6251
52	Hamamelidaceae	1	1	0.6251
53	Myricaceae	1	1	0.6251
54	Myristicaceae	1	1	0.6251
55	Proteaceae	1	1	0.6251
56	Punicaceae	1	1	0.6251
57	Turneraceae	1	1	0.6251
58	Valerianaceae	1	1	0.6251
59	Combretaceae	5	2	0.5391
60	Passifloraceae	9	3	0.4531
61	Vitaceae	9	3	0.4531
62	Clusiaceae	13	4	0.3671
63	Alstroemeriaceae	2	1	0.3536
64	Cannaceae	2	1	0.3536
65	Cecropiaceae	2	1	0.3536
66	Magnoliaceae	2	1	0.3536
67	Martyniaceae	2	1	0.3536
68	Musaceae	2	1	0.3536
69	Olacaceae	2	1	0.3536
70	Papaveraceae	2	1	0.3536
71	Plantaginaceae	2	1	0.3536
72	Podostemaceae	2	1	0.3536
73	Apiaceae	6	2	0.2676
74	Loganiaceae	6	2	0.2676
75	Caricaceae	3	1	0.0821
76	Ebenaceae	3	1	0.0821
77	Elaeocarpaceae	3	1	0.0821
78	Portulaccaceae	3	1	0.0821
79	Myrtaceae	29	8	0.0231
80	Celastraceae	7	2	−0.0039
81	Violaceae	7	2	−0.0039
82	Caryophyllaceae	4	1	−0.1894
83	Clethraceae	4	1	−0.1894
84	Dilleniaceae	4	1	−0.1894
85	Monimiaceae	4	1	−0.1894
86	Theaceae	4	1	−0.1894
87	Solanaceae	63	17	−0.2079
88	Polygonaceae	8	2	−0.2754
89	Alismataceae	1	0	−0.3749
90	Balanophoraceae	1	0	−0.3749
91	Betulaceae	1	0	−0.3749
92	Brunnellaceae	1	0	−0.3749
93	Cabombaceae	1	0	−0.3749
94	Casuarinaceae	1	0	−0.3749
95	Ceratophyllaceae	1	0	−0.3749

APPENDIX: CONTINUED.

Ranking	Plant family	Total species	Medicinal spp.	Residual
96	Chloranthaceae	1	0	−0.3749
97	Cunoniaceae	1	0	−0.3749
98	Haemodoraceae	1	0	−0.3749
99	Hernandiaceae	1	0	−0.3749
100	Hypoxidaceae	1	0	−0.3749
101	Juncaceae	1	0	−0.3749
102	Lacistemataceae	1	0	−0.3749
103	Lentibulariaceae	1	0	−0.3749
104	Molluginaceae	1	0	−0.3749
105	Najadaceae	1	0	−0.3749
106	Nymphaeaceae	1	0	−0.3749
107	Grossulariaceae	1	0	−0.3749
108	Plumbaginaceae	1	0	−0.3749
109	Polemoniaceae	1	0	−0.3749
110	Primulaceae	1	0	−0.3749
111	Pyrolaceae	1	0	−0.3749
112	Rafflesiaceae	1	0	−0.3749
113	Rhizophoraceae	1	0	−0.3749
114	Ruppiaceae	1	0	−0.3749
115	Saxifragaceae	1	0	−0.3749
116	Typhaceae	1	0	−0.3749
117	Tovariaceae	1	0	−0.3749
118	Vochysiaceae	1	0	−0.3749
119	Winteraceae	1	0	−0.3749
120	Zygophyllaceae	1	0	−0.3749
121	Brassicaceae	5	1	−0.4609
122	Lythraceae	5	1	−0.4609
123	Onagraceae	5	1	−0.4609
124	Ranunculaceae	5	1	−0.4609
125	Ulmaceae	5	1	−0.4609
126	Cactaceae	13	3	−0.6329
127	Burmanniaceae	2	0	−0.6464
128	Connaraceae	2	0	−0.6464
129	Cyclanthaceae	2	0	−0.6464
130	Dichapetalaceae	2	0	−0.6464
131	Gunneraceae	2	0	−0.6464
132	Hydrophyllaceae	2	0	−0.6464
133	Ochnaceae	2	0	−0.6464
134	Oleaceae	2	0	−0.6464
135	Sabiaceae	2	0	−0.6464
136	Staphyleaceae	2	0	−0.6464
137	Styracaceae	2	0	−0.6464
138	Theophrastaceae	2	0	−0.6464
139	Bignoniaceae	32	8	−0.7914
140	Aquifoliaceae	3	0	−0.9179
141	Convallariaceae	3	0	−0.9179
142	Erythroxylaceae	3	0	−0.9179
143	Gentianaceae	3	0	−0.9179
144	Juglandaceae	3	0	−0.9179

APPENDIX: CONTINUED.

Ranking	Plant family	Total species	Medicinal spp.	Residual
145	Pontederiaceae	3	0	−0.9179
146	Thymelacaceae	3	0	−0.9179
147	Campanulaceae	4	0	−1.1894
148	Hippocrateaceae	4	0	−1.1894
149	Icacinaceae	4	0	−1.1894
150	Marcgraviaceae	4	0	−1.1894
151	Potamogetonaceae	4	0	−1.1894
152	Scrophulariaceae	19	4	−1.2619
153	Dioscoreaceae	8	1	−1.2754
154	Ericaceae	8	1	−1.2754
155	Heliconiaceae	8	1	−1.2754
156	Iridaceae	8	1	−1.2754
157	Actinidiaceae	5	0	−1.4609
158	Annonaceae	20	4	−1.5334
159	Melastomataceae	46	11	−1.5924
160	Flacourtiaceae	17	3	−1.7189
161	Capparaceae	10	1	−1.8184
162	Myrsinaceae	18	3	−1.9904
163	Arecaceae	22	4	−2.0764
164	Araliaceae	11	1	−2.0899
165	Asclepiadaceae	19	3	−2.2619
166	Gesneriaceae	16	2	−2.4474
167	Boraginaceae	17	2	−2.7189
168	Bromeliaceae	38	6	−4.4204
169	Convolvulaceae	28	3	−4.7054
170	Moraceae	31	3	−5.5199
171	Cyperaceae	35	2	−7.6059
172	Rubiaceae	126	24	−10.3124
173	Poaceae	93	5	−20.3529
174	Orchidaceae	99	2	−24.9819