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Abstract

The ethnobotanical importance of the family Piperaceae is recognized mainly for its medicinal properties. A total of 106 species of two genera of this family (*Piper* and *Peperomia*) have been collected in Oaxaca, but only 18 are recorded in scientific publications as medicinal, edible, veterinary, or ritual plants. The objectives of this study are to describe the traditional knowledge and uses of the Piperaceae in areas of high biocultural diversity of Oaxaca and to analyze the relationship between its geographic distribution with ethnobotanical records among ethnic groups. Fieldwork was carried out between 2013 and 2016, and voucher specimens were reviewed in Mexican herbaria. Two multivariate analyses were applied to compare the geographic distribution of Piperaceae with ethnobotanical knowledge in Oaxaca. A total of 13 species of *Peperomia*, and 7 of *Piper* were collected, besides some unidentified species of both genera. Seven use categories were registered, with medicinal and edible being the most important. A high percentage (65%) of the species is named in at least one native language. Most species have a single use, mainly medicinal. *Peperomia* has been collected in Oaxaca since 1980, while *Piper* since 1960. Multivariate analysis indicated the existence of a differentiated ethnobotanical knowledge of this family among ethnic groups, related to the geographic distribution of species. This study evidences that ethnic groups, who maintain areas of higher biodiversity, obtain these species mainly from the wild, from specific microenvironments; hence, conservation practices must be reinforced for them, as for all ecosystems in general.

Keywords

ethnic group, ethnobotany, herbaria, *Piper*, *Peperomia*

Introduction

Mexico is considered among the 10 countries with the highest levels of biological and cultural diversity in the world (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad [CONABIO], 2019). Based on archaeological records, it is known that use and management of natural resources have occurred at least since 10,000 years ago (Flannery, 1986; MacNeish, 1992), which implies accumulative processes of learning, trying, selection, use, and management of those resources that were selected for different purposes. In addition, a philosophical context has evolved, which means that people have developed a cosmovision, in order to link this knowledge and practices with metaphysic concepts to give a sense to their surrounding world (Menzies & Butler, 2006). Ethnobotanical research has tried to understand that complex world, in order to interpret

and explain patterns and processes involved in it, and, as a consequence, different studies have been developed in areas of Mexico, attempting to know, understand, and explain that knowledge.

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Oaxaca is one of the five states with the highest biological richness in Mexico as well as one of the most important in terms of ethnic composition (De Ávila, 2004); hence, traditional knowledge has been recognized in different studies. In terms of floristic records, Oaxaca contains 40% of the Mexican flora, including 8,000 plant species (Pteridophytes, Gymnosperms, Angiosperms), distributed in 26 vegetation types (Mickel & Beitel, 1988; Torres-Colín, 2004) that represent 70% of all type of vegetation present in Mexico (García-Mendoza, Ordoñez, & Briones-Salas, 2004). Culturally, Oaxaca concentrates 30% of the ethnic groups present in Mexican territory. In this context, knowledge and use of plant resources have been part of their evolution and maintenance in different territories, with a range of different ecological, geological, and climatic conditions within this state. These are the reasons to classify Oaxaca in eight different territorial regions (Instituto Nacional para el Federalismo y el Desarrollo Municipal-Secretaría de Gobernación, 2010; Ordoñez, 2000) and in eight Priority Terrestrial Regions (PTRs) (Arriaga et al., 2000). Due to this complex biocultural diversity (Boege, 2008; Toledo et al., 2001), ethnobotanical research in Oaxaca has been developed during decades, focusing on different aspects (Brown & Chase, 1981; Cardoso, 2004; Cruz & Cruz, 1992; Hunn, 2008; Luna-José & Rendón-Aguilar, 2008; Luna-Morales, Aguirre, & Rogelio, 2001; Martin, 1996; Messer, 1978; Rendón-Aguilar, Bernal-Ramírez, & Bravo-Avilez, 2017; Rendón-Aguilar, Bernal-Ramírez, Bravo-Avilez, & Mendoza-Ruiz, 2017; Van der Wal, 1996; Ventura-Aquino, Rendón-Aguilar, Rebollar, & Hernández, 2008; Zizumbo & Colunga, 1982; among others). This is the case for ethnobotanical studies about traditional knowledge, use and management of different plant families, such as Piperaceae.

Recent floristic data indicate that from the 321 botanical families present in the state of Oaxaca, Piperaceae is among the 20 most species-rich ones, with two genera (*Peperomia* and *Piper*), and 106 species (García-Mendoza & Meave, 2011; Fonseca, 2011; Fonseca & Samain, 2011), which corresponds to 42% of the species of this family collected in Mexico (Villaseñor, 2016), and 2.9% of the total species recorded globally (Frenzke et al., 2015; Quijano-Abril, Callejas-Posada, & Miranda-Esquivel, 2006; Wanke et al., 2007). In addition to these records, a research project including a screening of the ethnofloristic richness in Oaxaca (Rendón-Aguilar, Bernal-Ramírez, & Bravo-Avilez, 2017) reported that the family Piperaceae is one of the 10 most useful families in Oaxaca, of a total of 142 families (Rendón-Aguilar, Bernal-Ramírez, & Bravo-Avilez, 2017; Rendón-Aguilar, Bernal-Ramírez, Bravo-Avilez, & Mendoza-Ruiz, 2017).

However, relatively few taxa have been reported with a traditional use in scientific literature, mainly in the states of Chiapas, Oaxaca, and Veracruz. In the case of *Piper*, ethnobotanical studies reported only six species: *Piper auritum* Kunth (Aguilar, Chino, Jaquez, & Lopez, 1994; Andrade-Cetto & Heinrich, 2005; Browner, 1985; Estrada-Reyes, Martínez-Laurrabaquio, Ubaldo-Suárez, & Araujo-Escalona, 2013; Frei, Baltisberger, Sticher, & Heinrich, 1998; García, Leyva, Martínez & Stashenko, 2007; Geck, 2018; Geck, Reyes-García, Casu, & Leonti, 2016; Joly, 1981; Martínez, 1969; Picó & Nuez, 2000; Salinas-Espinoza, Vásquez-Dávila, Romero-Santillán, Manzanero-Medina, 2017; Schultes & Hofmann, 2000); *Piper umbellatum* L. (Giovannini & Heinrich, 2009; Roersch, 2010); *Piper sanctum* (Miq.) Schltdl. ex C. DC.; *Piper marginatum* Jacq. (Picó & Nuez, 2000); *Piper amalago* L.; and *Piper unguiculatum* Ruiz & Pav. (Frei et al., 1998; Geck, 2018; Geck et al., 2016).

In the case of the genus *Peperomia*, previous ethnobotanical studies in Mexico reported: *Peperomia hernandifolia* (Vahl.) A. Dietr., *Peperomia hobbitoides* T. Wendt, *Peperomia peltilimba* C. DC. ex Trel., *Peperomia rotundifolia* (L.) Kunth., and *Peperomia berlandieri* Miq. (Luna-José & Rendón-Aguilar, 2012; Vergara-Rodríguez, Mathieu, Samain, Armenta-Montero, & Krömer, 2017); *Peperomia maculosa*, *Peperomia pellucida* (L.) Kunth, *Peperomia peltata* (L.) A. Dietr., *P. rotundifolia* (L.) Kunth (Giovannini & Heinrich, 2009; Mahiou et al., 1995), and *Peperomia nigropunctata* Miq. (Fournet et al., 1996; Giovannini & Heinrich, 2009).

For these reasons, the objectives of this work are to contribute to the ethnofloristic records of useful Piperaceae in Oaxaca, in areas of high biocultural diversity, and to analyze the relationship between the geographical distribution of this family and its ethnobotanical records among ethnic groups, in order to discard possible bias due to an oversampling during the development of this study within any of the PTRs.

Methods

Study Area

The study area comprised 84 municipalities (Figure 1) belonging to three of the eight PTRs proposed by Arriaga et al. (2000) for the state of Oaxaca, all of them characterized by a very rich ethnic composition and high levels of biodiversity. These municipalities were selected in order to obtain a representative sample of each PTR, trying to include most of the area occupied by each one (Bernal-Ramírez et al., 2019; Rendón-Aguilar, Bernal-Ramírez, & Bravo-Avilez, 2017; Rendón-Aguilar, Bernal-Ramírez, Bravo-Avilez, & Mendoza-Ruiz, 2017).

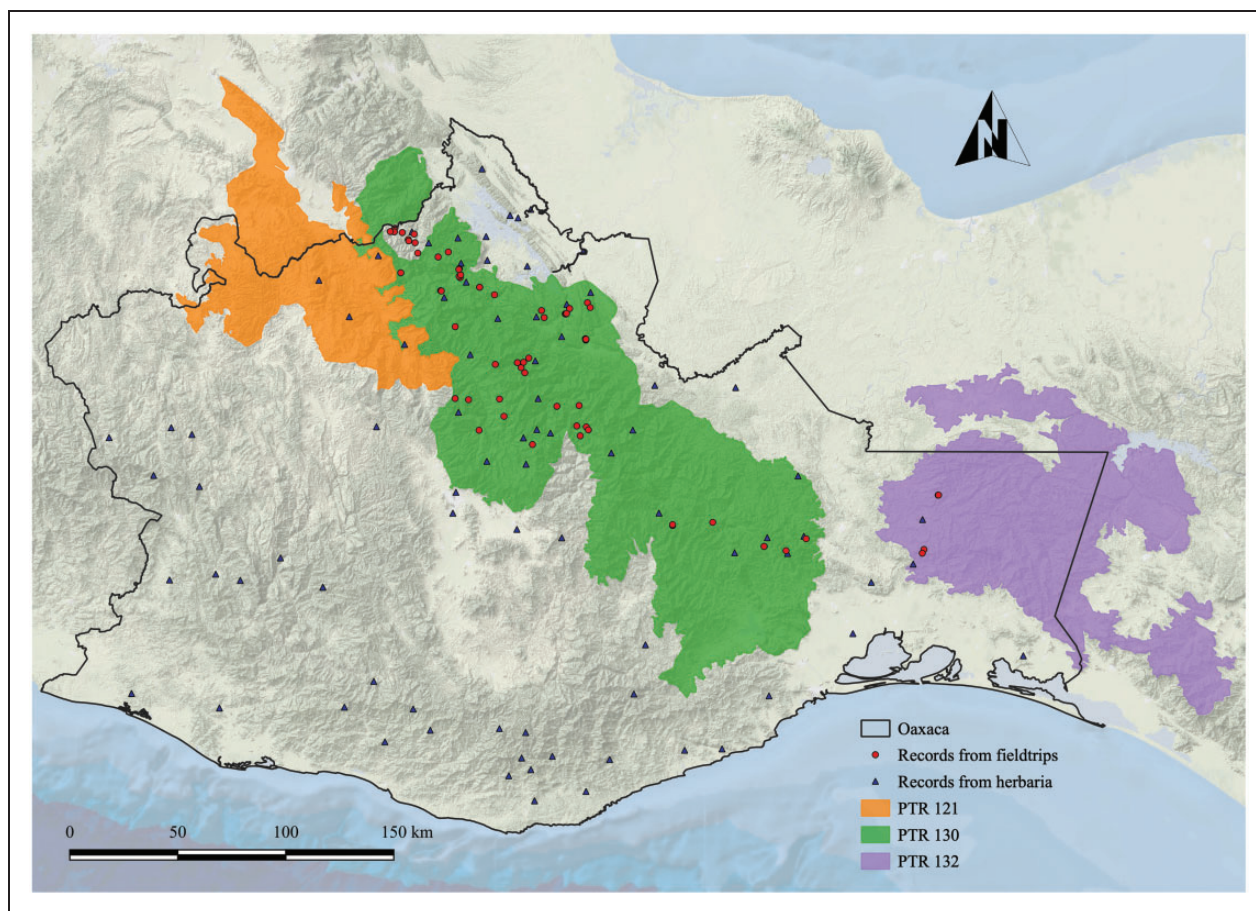


Figure 1. Map showing the study area in three PTRs of Oaxaca: PTR 121, Valle de Tehuacán-Cuicatlán; PTR 130, Sierras del Norte de Oaxaca-Mixe; PTR 132, Selva Zoque-La Sepultura. Red dots indicate localities from fieldtrips, and triangles represent herbarium specimens.

(Figure 1) (Online Appendix 1). These 84 municipalities represented 37% of the total (208) included in these regions (only for the state of Oaxaca):

PTR 121 (Valle de Tehuacán-Cuicatlán) includes 68 municipalities from Oaxaca (45) and Puebla (23). Municipalities of Oaxaca are inhabited by five ethnic groups: Cuicatec, Ixcatec, Mazatec, Nahua, and Mixtec. This region is characterized by the presence of an extensive area of semiarid vegetation in lowlands, such as xerophilous scrub and deciduous tropical forest, with a high proportion of endemism; highlands are represented by pine-oak forest and montane cloud forest. Municipalities of Oaxaca occupy more than half of this region (66.2%). We visited only five of these (11.1%), inhabited by Cuicatec, Mazatec, and Nahua.

PTR 130 (Sierras del Norte de Oaxaca-Mixe) includes 165 municipalities from Oaxaca, Puebla, and Veracruz. Those belonging to Oaxaca (156) are inhabited by Zapotec, Mixe, Chinantec, Nahua, and Mixtec ethnic groups, occupying the highest proportion of this region (94.5%). This region is characterized by a complex

landscape, with the presence of different ecosystems with low levels of fragmentation, such as different kinds of temperate and tropical forests (e.g., pine forest, oak forest and subdeciduous tropical forest, among others). Montane cloud forest has its highest area of distribution in this region, and it presents a high level of conservation. We visited 76 municipalities (46%), inhabited by the ethnic groups mentioned earlier.

PTR 132 (Selva Zoque-La Sepultura) includes 17 municipalities from Chiapas, Oaxaca, and Veracruz. Seven municipalities belong to Oaxaca and are inhabited by Zapotec and Zoque groups. It occupies one of the highest extensions of all PTR. It presents a complex mixture of different tropical forests in lowlands, montane cloud forest, and different template forests in highlands. We sampled only three municipalities (17.6%) represented by Zoque ethnic group.

The sampled areas also included four municipalities with Mestizo populations (San Pedro Teutila, Natividad and Santiago Xiacuí in PTR 130, and San Pedro Tapanatepec in PTR 132).

Ethnobotanical Information

In each of the 84 municipalities visited, we explained the purposes of the study to local authorities, asking for support of local guides who knew the area, the plants used currently and in the past, and their names in the local language and in Spanish, as well as for authorization to collect these species. As the project involved an ethnofloristic screening of 84 municipalities, we followed an “accidental sampling,” which is a nonprobabilistic sampling technique used in exploratory ethnobiological studies (Albuquerque et al., 2014). Two or three local guides, most of them were men ranging in age between 20 and 65 years, were designated by each municipal authority; female local guides were assigned only in four municipalities (Bernal-Ramírez et al., 2019; Rendón-Aguilar, Bernal-Ramírez, & Bravo-Avilez, 2017; Rendón-Aguilar, Bernal-Ramírez, Bravo-Avilez, & Mendoza-Ruiz, 2017). Ethnobotanical records came from about 200 local people. We also obtained permission to collect useful plants in preserved or sacred areas and in places with special ecological importance (e.g., near waterfalls, archaeological sites, and glens).

Fieldtrips of 10 to 12 days every 2 months were conducted for 3 years (2013–2016) to collect plants in all proposed municipalities (Rendón-Aguilar, Bernal-Ramírez, & Bravo-Avilez, 2017; Rendón-Aguilar, Bernal-Ramírez, Bravo-Avilez, & Mendoza-Ruiz, 2017). Due to the amplitude of the studied area, and the time restriction, each municipality was visited once (Bernal-Ramírez et al., 2019; Rendón-Aguilar, Bernal-Ramírez, & Bravo-Avilez, 2017; Rendón-Aguilar, Bernal-Ramírez, Bravo-Avilez, & Mendoza-Ruiz, 2017). As a consequence of these logistical limitations, in many cases, local guides noted useful species that did not show flowers and fruits at the time of the fieldwork, which were neither collected nor recorded.

Each specimen with flowers and fruits which was recognized by local guides as useful was photographed and collected, and ecological and geographical data were recorded, including date, municipality, locality, geographic coordinates, altitude, type of vegetation, visual soil characteristics, biological data of each species (habitat, size, growth form, and characteristics of reproductive structures), common name(s), use(s), use categories, parts of plants used, and descriptions of their use. All specimens were numbered, placed temporarily in brown paper bags, and later processed for transportation. Once in the laboratory, specimens were dried appropriately and distributed to specialists for their taxonomic identification.

Identification and Deposition of Plant Specimens

Herbarium specimens were reviewed and identified with specialized keys, whenever possible. One specimen was

labeled, mounted, and deposited in the herbarium UAMIZ of the Metropolitan Autonomous University, Iztapalapa, Mexico City. Duplicates will be distributed to the National Herbarium of Mexico (MEXU) of the National Autonomous University of Mexico, the herbarium OAX, Interdisciplinary Research Center for Integral Development Regional Unit of Oaxaca (CIIDIR-Oaxaca), and the Institute of Ecology Herbarium, Pátzcuaro, Michoacán (IEB).

Ethnobotanical Information of Field Collections During the Project

Field information was systematized in an Excel database in order to analyze traditional knowledge, measured as the species recognized with any use, their names in a local language (De Ávila, 2004) and in Spanish, use categories and the forms of use or preparation. In addition, the information for each specimen was integrated into the database BIÓTICA © 5.0.3 (CONABIO, 2012). Photographs of specimens taken in the field were deposited in the image bank of CONABIO.

Ethnobotanical Information of Herbarium Specimens

All specimens of this family collected in Oaxaca were reviewed in the collection of the National Herbarium of Mexico (MEXU), and the herbaria of the Institute of Ecology, A.C. in Xalapa (XAL), and Pátzcuaro (IEB), and the information of the labels was captured, from which an Excel database was created with the following columns: state, municipality, locality, geographical coordinates, altitude, type of vegetation, and habitat, as well as ethnobotanical information in case of existence. This information was used to compare our findings with those previously reported and to check their geographic distribution. In addition, the electronic database of the National Herbarium of Mexico was reviewed, and the same information was recorded.

Ethical Authorization

The CONABIO (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad), through the Subcoordination of Information and Analysis, provided approval of all results reported in project JF102 “Inventario etnoflorístico en regiones oaxaqueñas con gran biodiversidad” (Of. No. DGP/787/16).

Data Analysis

Data were analyzed to obtain the number of useful species recorded in these genera, common name (local language or Spanish), and use categories. From the 84 municipalities visited during the project, we obtained specimens of Piperaceae from 45 municipalities.

To compare compositional similarity between our field collections of both genera in Oaxaca with the geographic distribution of the family recorded in herbaria specimens in order to discard a possible bias due to oversampling in any of the three PTR during the fieldtrips, we followed a nonmetric multidimensional scaling analysis (nMDS, using Jaccard index in PAST 3.2 software; Ø. Hammer, Harper, & Ryan, 2001). This is a nonparametric rank-based approach for graphically representing relationships between kinds of samples in a multidimensional space through dissimilarity measure (Quinn & Keough, 2002) and is an appropriate ordination method for not normal distribution data or those with a discontinuous or arbitrary scale. In addition, a centered principal component analysis in a correlation matrix was performed to characterize possible clustering through plant species and ethnic groups and vegetation type (Bernal-Ramírez et al., 2019; Rendón-Aguilar, Bernal-Ramírez, & Bravo-Avilez, 2017; Rendón-Aguilar, Bernal-Ramírez, Bravo-Avilez, & Mendoza-Ruiz, 2017).

Results

Ethnobotanical, ecological, and floristic information about Piperaceae in Oaxaca came from 45 municipalities (53.6% of the total area visited), all of them corresponding to new localities for any of the species collected, and from seven ethnic groups: Cuicatec, Chinantec, Mazatec, Mixe, Nahua, Zapotec, Zoque, as well as the Mestizo group.

Ethnobotanical Aspects of the Piperaceae Family in Oaxaca

Number of useful Piperaceae. Seventy-one specimens were collected corresponding to 20 species, 6 affinities, and 15 specimens identified only to genus level. We found 25 specimens of the genus *Peperomia*, belonging to 13 species, 4 affinities, and 8 specimens identified at genus level. In the case of *Piper*, 16 specimens were collected: seven species, two affinities, and seven identified to genus (Table 1).

Common name (local language or Spanish). Eleven of the 17 species and all affinities of the genus *Peperomia* are named in at least one language, and of these, 7 also have a name in Spanish. Two species receive Spanish names only (Table 1). In the case of *Piper*, of the seven species and the two affinities, almost all are named in a native language and in Spanish, except *Piper* aff. *uhdei* which is named only in Spanish.

Use categories. Seven use categories were recorded. Species of both genera are mainly applied for medicinal purposes; the rest of the uses present variations between

both genera. Hence, it is noteworthy that five species of the genus *Peperomia* are used as fresh (vegetable), or processed (seasoning) food, whereas in the genus *Piper*, only *P. auritum* is utilized in this form. In addition, only species of *Piper* are used as firewood, for construction, or for a veterinary purpose, and only three species of *Peperomia* are used as ornamentals (Figure 2(a)).

The medicinal use includes treatments as diverse as acne elimination, childbirth recovery, toothache relief, stomach pain, and erysipelas symptoms, among others (Table 1). Even two species of the genus *Piper* (i.e., *Piper aduncum*, and *P. auritum*) are employed against snakebites.

The ceremonial use corresponds to the species *P. amalago*, *Peperomia obtusifolia*, and *Peperomia quadrangularis* and is related to the treatment of psychosomatic diseases such as evil wind (“mal aire”) or evil eye (“mal de ojo”). These ailments include symptoms such as headache, stomach spasms, chest tightness, teary eye, and anxiety. In addition, they usually refer to extreme anxiety or panic attacks (“susto”) that can occur when, for example, a snake crosses one’s path, or when someone surprises his partner in infidelity. In both cases, people are fatigued, sleepy, and they lose hair and weight, among other symptoms. Moreover, these species are placed on the altars of saints, alone or in association with mosses during and after religious celebrations. Plants used as ornamentals are usually placed in a pot or in the garden of the house (e.g., *P. maculosa*, *Peperomia pseudoalpina*, *P. rotundifolia*). Edible plants can be eaten on their own, such as fresh vegetables, or added to beans or tamales. Such is the case of *P. hernandiifolia*, *P. maculosa*, *Peperomia pecuniifolia*, and *P. quadrangularis*, as well as *P. auritum*. For construction, the stems of *P. aduncum* are used as the support of palm thatch roofs. The veterinary use corresponds to *Piper peltatum*, whose macerated leaves are smeared on the skin of affected dogs to combat scabies. For fuelwood, the thick stems of *Piper lapathifolium* are frequently used (Table 1).

In relation to the number of uses, most species of *Peperomia* have only one, which, as already mentioned, is mainly medicinal, edible, ceremonial, or ornamental. *P. maculosa* and *P. quadrangularis* have two uses: edible-ornamental and edible-ceremonial, respectively. Of the seven species of the genus *Piper*, six have medicinal uses and three have a dual one: *P. aduncum*, medicinal-construction, *P. auritum*, medicinal-edible, and *P. lapathifolium*, medicinal-fuel (Figure 2(b)).

Ethnobotanical Knowledge Recorded on Herbarium Specimens

The information obtained in the herbaria shows that most species of both genera, except for

Table 1. Uses, forms of Use, and Distribution of the Family Piperaceae in Oaxaca (Rendón-Aguilar, Bernal-Ramírez, & Bravo-Avilés, 2017).

Species	Local name (Spanish/local language)	Ethnic group	Category of use	Use	Qualitative appreciation of abundance	Municipalities	Type of vegetation, altitude (m asl)	Municipalities recorded in voucher specimens (MEXU, XAL, IEB)	Uses reported in voucher specimens
<i>Peperomia</i> <i>Peperomia alpina</i> (Sw.) A. Dietr.	nr	mi	M	Skin grains	Scarce	Stgo. Zacatepec	PTF 1672–	San Pedro Ocotepes, Stgo. Comaltepec, Totontepec Villa de Morelos	nr
<i>Peperomia</i> <i>Peperomia blanda</i> (Jacq.) Kunth	nr	cui	M	Anxiety or panic	Scarce	San Andrés Teotilalpam	MCF 1163–	Capulalpam de Méndez, San Jerónimo Coatlán, San Jerónimo Sosola, San José Chiltepec, San Juan Bautista Valle Nacional, San Juan Juquila Vijanos, San Miguel Suchixtepec	nr
<i>Peperomia</i> <i>Peperomia clavigera</i> Standl. & Steyerlm.	sp, ch	ch	M	Stomach ache	Scarce	San Felipe Usila	SDTF 529–	San José Chiltepec, San Lucas Ojitlán	nr
<i>Peperomia</i> <i>Peperomia hernandiifolia</i> (Vahl) A. Dietr.	sp, mi, ch	mi, ch	F	Fresh leaves eaten or added to cooked beans, tamales and memelas	Scarce to medium	San Miguel Quetzaltepec, San Pedro Sochiápam, San Pedro Teutila, San Pedro Yólox Sta. Cruz Acatepec	MCF, PF, PEF 1291–1830	San Miguel del Puerto	nr
<i>Peperomia</i> <i>Peperomia leptophylla</i> Miq.	ma	ma	M	Teeth ache	Scarce		OF 1967–	Asunción Ixtaltepec, Ixtlán de Juárez, San Andrés Chichahuastla, San Juan Evangelista Analco, San Martín de las Peras, San Miguel Suchixtepec, Sta. Ma. Yavesía, Stgo. Textitlán, Stgo. Yosondúa, Totontepec Villa de Morelos	nr
<i>Peperomia</i> <i>Peperomia maculosa</i> (L.) Hook.	sp	mi, za	F, O	Fresh leaves	Scarce to medium	Guevea de Humboldt, San Miguel Quetzaltepec	OF, MCF 1164–1314	Guevea de Humboldt, San Miguel Chimalapa, Stgo. Domingo Tehuantepec	nr
<i>Peperomia</i> <i>Peperomia obtusifolia</i> (L.) A. Dietr.	sp, za	za	C	To decorate saints' altars.	Medium	Sta. Ma. Guienagati	MCF 1274–	Acatlán de Pérez Figueroa, Guevea de Humboldt, Huautla de Jiménez, Ixtlán de Juárez, Jesús Carranza, Juchitán de Zaragoza, Nuevo Soyaltepec, San Bartolomé Ayautla, San Felipe Usila, San Jerónimo Coatlán, San Juan Bautista Valle	nr

(continued)

Table 1. Continued.

Species	Local name (Spanish/local language)	Ethnic group	Category of use	Use	Qualitative appreciation of abundance	Municipalities	Type of vegetation, altitude (m asl)	Municipalities recorded in voucher specimens (MEXU, XAL, IEB)	Uses reported in voucher specimens
<i>Peperomia pecuniifolia</i> Trel. & Standl	sp, za	za	F	Added to cooked beans	Medium	Sta. Ma. Jaltianguis	POF 3020–	Nacional, San Juan Comaltepec, San Miguel del Puerto, San Miguel Soyaltepec, San Pedro Ocotepéc, Sta. Ma. Chimalapa, Sta. Ma. Güenagati, Sta. Ma. Jacatepec, Stgo. Comaltepec, Stgo. Lachiguiri, Sto. Domingo Tehuantepec, Torantepec Villa de Morelos, Vista Hermosa	nr
<i>Peperomia petilimba</i> C. DC. ex Trel	ch	ch	M	Inflamed feet	Medium	Sta. Ma. Jacatepec	PTF 320–	Without record in herbarium Reported only for Oaxaca, without specification (Villasenor, 2016) Guevea de Humboldt, Ixtlán de Juárez, San Felipe Usila, San José Tenango, San Juan Bautista Valle Nacional, Sta. Ma. Zacatepec, Stgo. Comaltepec, Stgo. Lachiguiri, Torantepec Villa de Morelos	F: edible leaves V: remove worms in cows
<i>Peperomia pseudopalpina</i> Trel.	sp	za	O	Nr	Medium	Guevea de Humboldt	MCF 1164–	San José Tenango, Stgo. Comaltepec	nr
<i>Peperomia quadrangularis</i> (J. V. Thoms.) A. Dietr. ^a	za, ma	za, ma	F, C	Fresh leaves are eaten; For bad air	Scarce to High	San José Tenango, San Miguel Abejones, San Miguel Aloápam, Stgo. Xiacuí	OPF, POF, SDTF 1424–2941	Without record	nr
<i>Peperomia quadrifolia</i> (L.) Kunth	nr	ma	nr	Nr	Not indicated	San Francisco Huehuetlán	MCF 2200–	Guevea de Humboldt, Hautla de Jiménez, Ixtlán de Juárez, San Felipe Usila, San Jerónimo Coatlán, San Juan Bautista Cuicatlán, San Juan Comaltepec,	F, C

(continued)

Table 1. Continued.

Species	Local name (Spanish/local language)	Ethnic group	Category of use	Use	Qualitative appreciation of abundance	Municipalities	Type of vegetation, altitude (m asl)	Municipalities recorded in voucher specimens (MEXU, XAL, IEB)	Uses reported in voucher specimens
<i>Peperomia rotundifolia</i> (L.) Kunth	nr	cui	O	Decoration of saints' altars, Niño Dios (along with moss)	Medium	San Andrés Teotilalpam	MCF 1163–	San Juan Guichicovi, San Mateo Río Hondo, San Miguel Aloápam, San Miguel Yotao, San Pedro Tapanatepec, San Pedro Teutila, Sta. Catarina Ixtepeji, Sta. Cruz Itundujia, Sta. Ma. Ixcatlán, Sta. Ma. Zacatepec, Stgo. Comaltepec, Stgo. Lachiguiri, Stgo. Textitlán, Stgo. Yaitepec, Taneze de Zaragoza, Tepelmeme Villa de Morelos, Totontepec Villa de Morelos	M
<i>P. aff. blanda</i> (Jacq.) Kunth	sp, ma, ch	ma, ch	M	To eliminate mud; for labor recovery	Scarce	San Juan Quiotepec, San Lorenzo Cuanequititla	MCF, POF 2052–2354	Huautla de Jiménez, San Felipe Usila, San José Tenango, Stgo. Comaltepec, Sta. Ma. Chimalapa	
<i>Peperomia aff. glabella</i> (Sw.) A. Dietr.	sp, ch	ch	M	Erysipelas	Scarce	San Juan Bautista Valle Nacional	PTF 617–		
<i>Peperomia aff. glabra</i> C. DC.	sp, cui	cui	O	To decorate houses	Scarce	San Andrés Teotilalpam	MCF 1163–		
<i>P. aff. leptophylla</i> Miq.	ch	ch	M, C	Rheumatism, dysen- tery, anxiety or panic	Scarce	San Juan Quiotepec	MCF 2354–		
Piper <i>Piper aduncum</i> L.	sp, ch, za	ch, za	CO, M	Cold, snakebite, roof support	Scarce to medium	San Cristóbal Lachirioag, San Ildefonso Villa Alta, San Pedro Yólox, Sta. María Jacatepec, Stgo. Comaltepec	OF, MCF, PTF, SDTF 265–1332	Acatlán de Pérez Figueroa, Guevea de Humboldt, Ixtlán de Juárez, Jamiltepec, Jamiltepec- Pinotepa Nacional, Pochutla y Candelaria Loxicha, Putla Villa de Guerrero, San Gabriel Mixtepec, San Jerónimo	nr

(continued)

Table 1. Continued.

Species	Local name (Spanish/local language)	Ethnic group	Category of use	Use	Qualitative appreciation of abundance	Municipalities	Type of vegetation, altitude (m asl)	Municipalities recorded in voucher specimens (MEXU, XAL, IEB)	Uses reported in voucher specimens
<i>Piper amalago</i> L.	sp. mi	mi	C	Evil eye	Medium	Stgo. Ixcuintepec	SDTF 624–	Coatlán, San Juan Comaltepec, San Mateo Piñas, San Miguel del Puerto, San Miguel Soyaltepec, San Pedro Ixcatlán, San Pedro Juchatengo, San Pedro Teutila, San Sebastián Coatlán, Sta. Cruz Itundujia, Sta. Ma. Chimalapa, Sta. Ma. Ecatepec, Sta. Ma. Tlalixtac, Stgo. Comaltepec, Stgo. Astata, Stgo. Juxtlahuaca, Stgo. La Galera, Soyaltepec, Soyolapan, Temascal, Tuxtepec - Jalapa de Díaz, Totontepec Villa de Morelos Eloxochitlán de Flores Magón, Huautla de Jiménez, San Bartolo Yautepec, San Felipe Jalapa de Díaz, San Jerónimo Coatlán, San José Chiltepec, San Juan Bautista Valle Nacional, San Juan Comaltepec, San Juan Guichicovi, San Lucas Ojitlán, San Miguel del Puerto, San Miguel Soyaltepec, San Miguel Suchixtepec, San Pedro Huanmelula, San Pedro Teutila, Sta. Ma. Chimalapa, Sta. Ma. Ecatepec, Sta. Ma. Jacatepec, Stgo. Comaltepec, Stgo. Jamiltepec, Stgo. Juxtlahuaca, Stgo.	M: To relief fever, scare, body pain, dry caught C: "bad eye"

(continued)

Table 1. Continued.

Species	Local name (Spanish/local language)	Ethnic group	Category of use	Use	Qualitative appreciation of abundance	Municipalities	Type of vegetation, altitude (m asl)	Municipalities recorded in voucher specimens (MEXU, XAL, IEB)	Uses reported in voucher specimens
<i>Piper auritum</i> Kunth	sp, cui, zo, ma, mi, na, za	cui, ma, mi, na, za	F, M	Leaves added to dif- ferent dishes: chicken and fish soup, mole, tam- ales, chilatole, mix- iotes, tezmole. Fresh stem is eaten. Hemorrhage, diar- rhea, Anger, snake- bite, pressure in the ears	Scarce to high	Huauatepec, Mazatlán Villa de Flores, San Francisco Chapulapa, San Juan Cotzocon, San Miguel Chimalapa, San Pedro Teutila, Sta. Cruz Acatepec, Sta. María Teopoxco, Stgo. Camotlán, Stgo. Texcalcingo, Sto. Domingo Roayaga, Teococuico de Marcos Pérez	OF, OPF, GV, POF, MCF, PTF, DTF, SDTF 342–1928	Domingo Petapa, Sto. Domingo Tehuantepec Asunción Ixtaltepec, Eloxochitlán, Ixtlán de Juárez, Oax. de Juárez, San Felipe Jalapa de Díaz, San José Tenango, San Juan Bautista Valle Nacional, San Juan Comaltepec, San Juan Guichicovi, San Juan Mixtepec, San Juan Quiotepec, San Lorenzo Albarradas, San Lucas Ojitlán, San Miguel Soyaltepec, Sta. Cruz Iteundujia, Sta. Cruz Xoxocotlán, Sta. Ma. Huautulco, Sta. Ma. Ixcatlán, Stgo. Camotlán, Stgo. Comaltepec, Stgo. Juxtlahuaca, Stgo. Pinotepa Nacional, Stgo. Textitlán, Sto. Domingo Petapa, Sto. Domingo Roayaga, Sto. Domingo Tehuantepec, Sto. Domingo Yodohino, Santos Reyes Tepejillo, Tlacolula de Matamoros, Totontepec Villa de Morelos	M: To relief fever; to relief hot body after a dead person is charged; skin and vaginal infections F: edible buds, stems, and leaves and seasoningg
<i>Piper lapathifolium</i> (Kunth) Steud.	sp, ch	ch	M, FU	Diarrhea, fuel		San José Chiltepec, San Juan Bautista Valle Nacional	PTF 430–461	San Juan Bautista Valle Nacional, San Felipe Usila, San José Tenango, San Lucas Ojitlán, Santa María Jacatepec, Yaveo Sta. Ma. Huatulco	nr
<i>Piper peltatum</i> L.	sp, ch	ch	V	Scabies	Medium	Sta. Ma. Jacatepec	PTF 219–		nr
<i>Piper schiedeanum</i> Steud.	sp, ch	ch	M	Rheumatism	Medium	Sta. Ma. Jacatepec	PTF 78–	San José Chiltepec, San Juan Bautista Valle Nacional, San Miguel Soyaltepec,	M: snakebite

(continued)

Table 1. Continued.

Species	Local name (Spanish/local language)	Ethnic group	Category of use	Use	Qualitative appreciation of abundance	Municipalities	Type of vegetation, altitude (m asl)	Municipalities recorded in voucher specimens (MEXU, XAL, IEB)	Uses reported in voucher specimens
<i>Piper umbellatum</i> L.	sp, ch, ma, za	ch, ma, za	M	Skin grains; muscular pain; stomach ache; clean skin	Scarce	Eloxochitlán de Flores Magón, Huautla de Jiménez, San José Chiltepec, San Juan Yaeé	MCF, OF, POF, PTF 227–1632	Sta. Ma. Chimalapa, Sta. Ma. Jacatepec, Yecuatla Acatlán de Pérez Figueroa, Candelaria Loxicha, Ixtlán de Juárez, Pluma Hidalgo, San Bartolo Yautepec, San Felipe Usila, San Jerónimo Coatlán, San José Tenango, San Juan Lalana, San Miguel Chimalapa, San Miguel del Puerto, San Miguel Soyaltepec, San Pedro Ixcatlán, Sta. Cruz Itundujia, Sta. Ma. Huautlco, Stgo. Textitlán	nr
<i>P. aff. schiede- num</i> Steud.	sp, ch	ch	M	Stomach ache	Scarce	Sta. Ma. Jacatepec	PTF 320–	Reported only for Oaxaca, without specification (Villaseñor, 2016)^b	
<i>Piper aff. uhdei</i> C. DC.	sp	zo	FU	Fuel	High	Sta. Ma. Chimalapa	PTF 405–	Reported only for Oaxaca, without specification (Villaseñor, 2016)^b	

Note. MEXU = National Herbarium of Mexico; XAL = the herbaria of the Institute of Ecology, A.C. in Xalapa; IEB = Institute of Ecology Herbarium, Páizcuaro, Michoacán; SDTF = subdeciduous tropical forest; PTF = perennial tropical forest; MCF = montane cloud forest; POF = pine-oak forest; OF = oak forest.

^aMeans new records for Oaxaca.

^bNo information of herbaria was included for specimens with *affinis*, due to the absence of taxonomic classification. Cuicatec (cui); Chinantec (ch); Mazatec (ma); Mixe (mi); Náhuatl (na); Spanish (sp); Zapotec (za); Zoque (zo); Not recorded (nr). Ceremonial (C); Construction (CO); Food (F); Fuel (FU); Medicine (M); Ornament (O); Veterinary (V). MEXU (National Autonomous University of Mexico); XAL (Institute of Ecology-Xalapa); IEB (Herbarium of the Regional Center of the Bajío, Institute of Ecology).

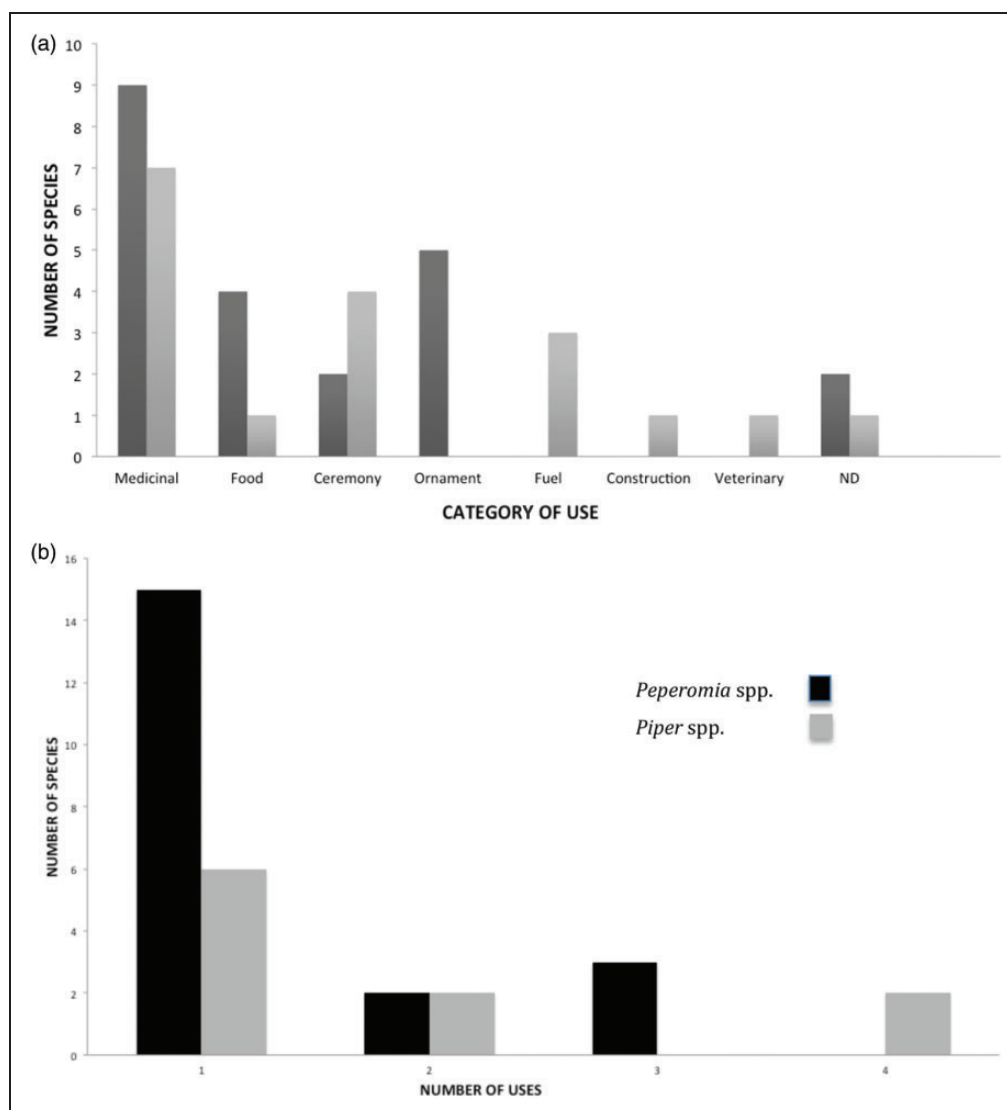


Figure 2. Uses of the family Piperaceae in the state of Oaxaca: (a) Use categories recorded during field trips and (b) number of uses.

P. quadrangularis, have previously been collected in several municipalities of the state, either in one to three municipalities (e.g., *Peperomia alpina*, *P. hernandii-folia*, *P. maculosa*, *P. pseudoalpina*, *P. lapathifolium*, and *P. peltatum*) or with more than 20 records (e.g., *P. obtusifolia* and *Peperomia quadrifolia*, *P. aduncum*, *P. amalago*, *P. auritum*). However, all the specimens collected in this study represent new records within the area sampled during this study (Table 1). It is worth mentioning that of the 11 species with herbarium records of the genus *Peperomia* exclusively for the state of Oaxaca, a little more than 70% were collected from the 1980s onwards. In the case of *Piper*, almost 60% of the species were collected from the decade of the 1960s onwards.

The ethnobotanical information available on herbarium specimens is scarce. As indicated, only three species of *Peperomia* recorded food, veterinary, ceremonial and medicinal use (*P. peltilimba*, *P. quadrifolia*, *P. rotundifolia*) and only three species of *Piper* recorded some use (*P. amalago*, *P. auritum*, *Piper schiedeanaum*), mainly medicine and food (Table 1).

The nMDS analysis shows that the voucher specimens, as well as our records from fieldwork of the two genera of Piperaceae, do mainly overlap on the plot (Figure 3). Dots outside the 95% confidence ellipses correspond to geographic areas of northeast Oaxaca that were visited and sampled for the first time. The principal component analysis displays at least two groups of Piperaceae species (Figure 4). With respect to the first component, the left

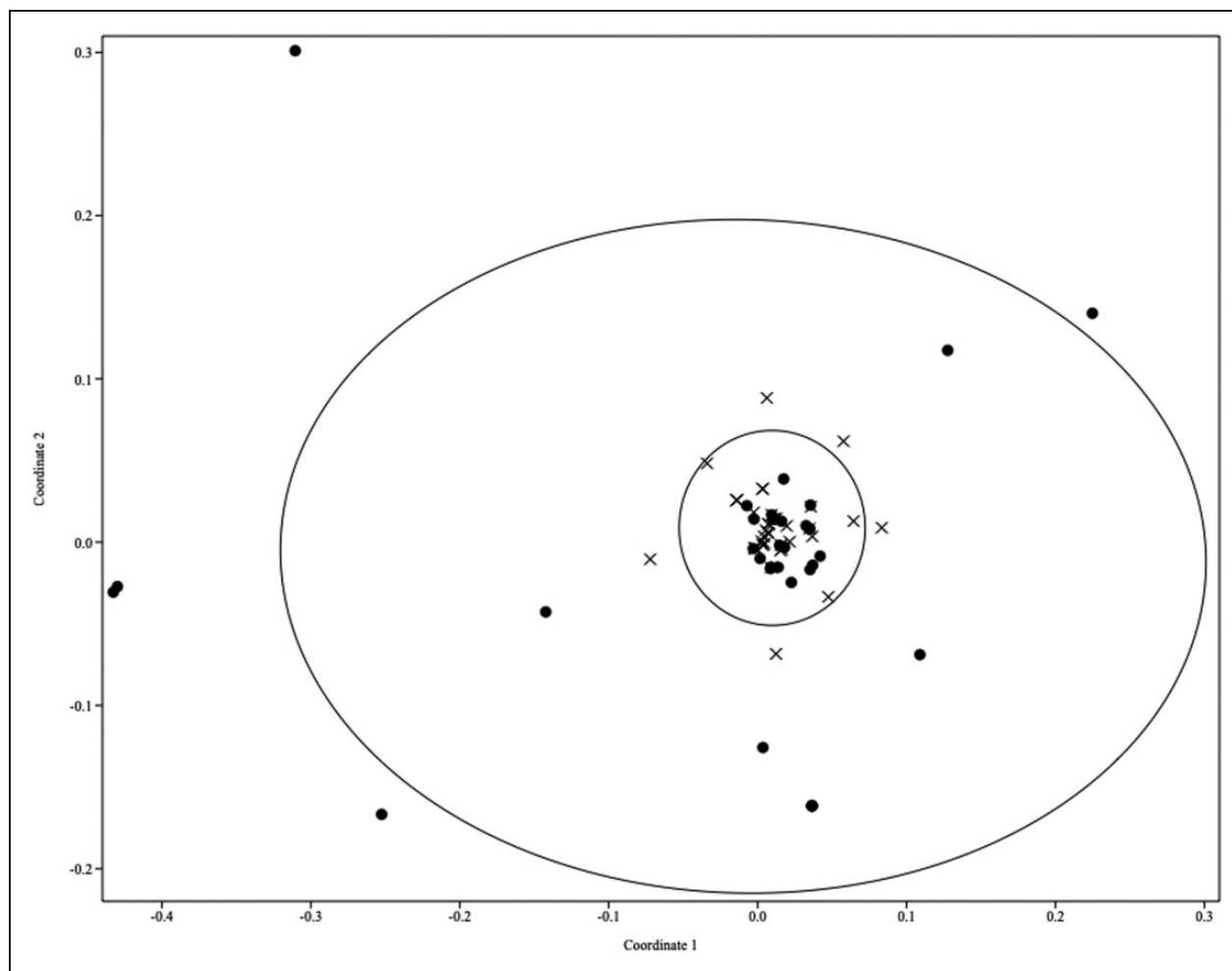


Figure 3. The nMDS scatter plot using Jaccard index. Dots represent plants collected during field trips, and crosses refer to herbarium specimens (stress = 0.689).

section shows species used by Chinantec and Zoque ethnic groups, associated to perennial tropical forest (PTF) and subdeciduous tropical forest, and distributed in lowlands below 1,000 m a.s.l.; the section at the right groups species distributed in temperate zones, with pine-oak forest, oak-pine forest, and oak forest, used by Zapotec and Mazatec ethnic groups. The second component separates, in the lower right section, those useful species collected in montane cloud forest, which are not associated with a specific ethnic group. This means that montane cloud forest in Oaxaca is a germplasm reservoir to the different ethnic groups, and even when they frequently gather natural resources from this type of vegetation, it still remains as one of the most important plant cover areas in Oaxaca (CONABIO, 2010).

Discussion

This study resumes ethnobotanical knowledge of 26 useful species and affinities of family Piperaceae in

Oaxaca, as well as new records of 17 species (5 species from *Piper* and 12 from *Peperomia*), collected in 45 municipalities, from the 84 visited between 2013 and 2016, in different biocultural regions of this state, inhabited by seven ethnic groups, and four municipalities conformed by the Mestizo group. These records represent more than those existing in previous literature for Oaxaca (from 1982 to the present). In addition, this is the first record of five useful species of Piperaceae within Mixe communities (*P. alpina*, *P. hernandiifolia*, *P. maculosa*; *P. amalago*, and *P. auritum*).

Ethnobotanical, taxonomic, and ecological relevance of this family for Oaxaca is remarkable due to the fact that many species are gathered from the wild. The ecological statuses of most of them are unknown; nevertheless, they grow in specific microhabitats, or on specific phorophytes, and our qualitative evaluation indicates that their populations are scarce (Table 1), so it is possible they are at risk due to deforestation, habitat fragmentation, or over-gathering, as indicated in other

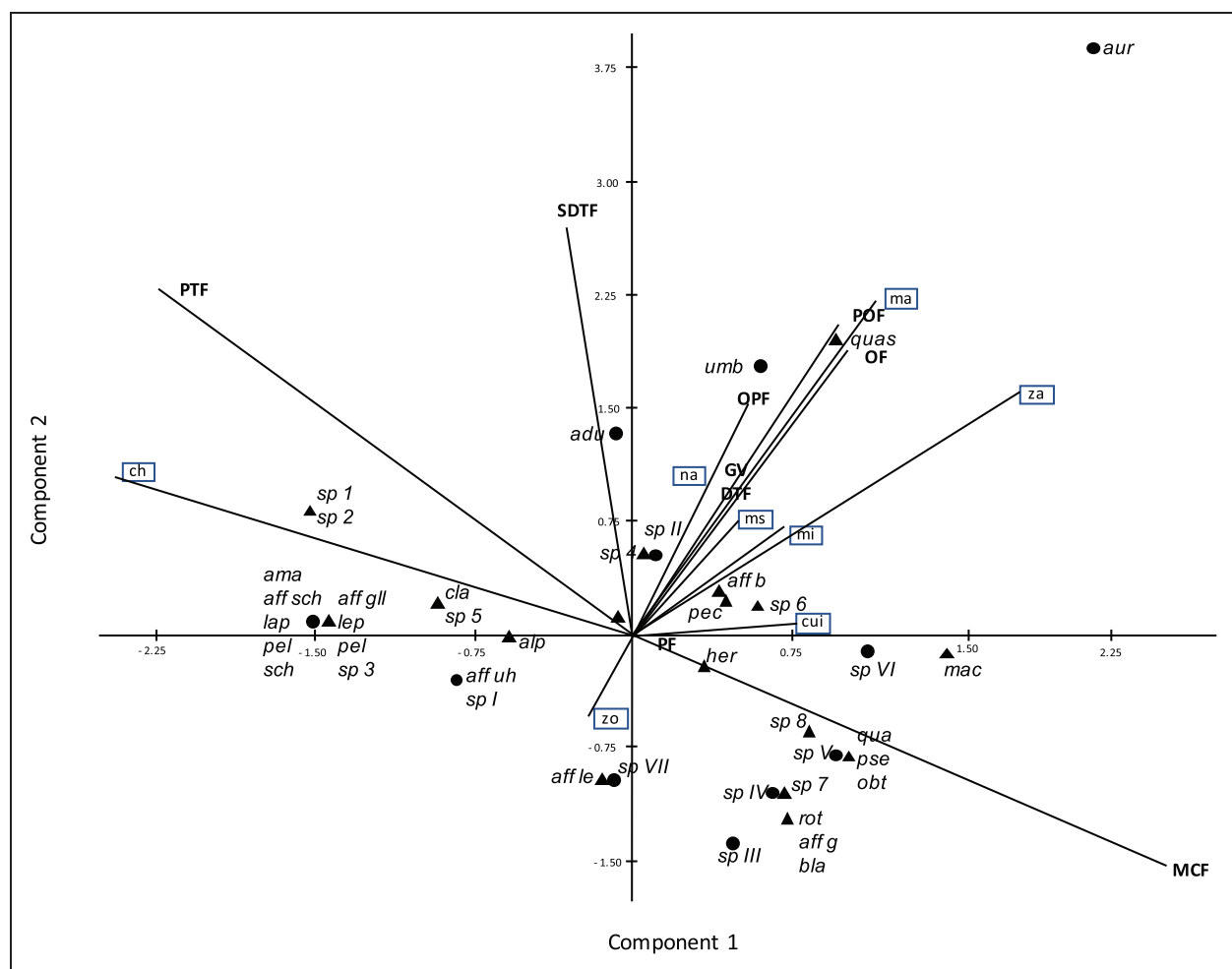


Figure 4. Principal component analysis scatter plot for plant species and ethnic group—vegetation type. The first two axes explained 42.6% of the variance, exhibiting two weak grouping. Abbreviations and acronyms: *Peperomia* aff. *blanda* (aff b), *Peperomia* aff. *glabella* (aff gl), *Peperomia* aff. *glabra* (aff g), *Peperomia* aff. *leptophylla* (aff le), *Peperomia* *alpina* (alp), *Peperomia* *blanda* (bla), *Peperomia* *clavigera* (cla), *Peperomia* *hernandiifolia* (her), *Peperomia* *leptophylla* (lep), *Peperomia* *maculosa* (mac), *Peperomia* *obtusifolia* (obt), *Peperomia* *pecuniifolia* (pec), *Peperomia* *peltolimba* (pel), *Peperomia* *pseudoalpina* (pse), *Peperomia* *quadrangularis* (quas), *Peperomia* *quadrifolia* (qua), *Peperomia* *rotundifolia* (rot), *Peperomia* sp.1 (sp 1), *Peperomia* sp.2 (sp 2), *Peperomia* sp.3 (sp 3), *Peperomia* sp.4 (sp 4), *Peperomia* sp.5 (sp 5), *Peperomia* sp.6 (sp 6), *Peperomia* sp.7 (sp 7), *Peperomia* sp.8 (sp 8), *Piper* *aduncum* (adu), *Piper* aff. *schiedeanum* (aff sch), *Piper* aff. *uhdei* (aff uh), *Piper* *amalago* (ama), *Piper* *auritum* (aur), *Piper* *lapathifolium* (lap), *Piper* *peltatum* (pel), *Piper* *schiedeanum* (sch), *Piper* *umbellatum* (umb), *Piper* sp.1 (sp I), *Piper* sp.2 (sp II), *Piper* sp.3 (sp III), *Piper* sp.4 (sp IV), *Piper* sp.5 (sp V), *Piper* sp.6 (sp VI), *Piper* sp.7 (sp VII). ▲ = *Peperomia*, ● = *Piper*. PTF = perennial tropical forest; MCF = montane cloud forest; SDTF = subdeciduous tropical forest; PF = pine forest; POF = pine-oak forest; OF = oak forest; OPF = oak-pine forest; GV = gallery vegetation; DTF = deciduous tropical forest; MV = meadow vegetation; OyF = oyamel forest; XS = xerophilous scrub; cui = Cuicatec; ch = Chinantec; ma = Mazatec; mi = Mixe; na = Náhuatl; ms = Mestizo; za = Zapotec; zo = Zoque.

studies (Arellanes et al., 2013; Blancas, Casas, Pérez-Salicrup, Caballero, & Vega, 2013; Vergara-Rodríguez et al., 2017). Commercialization could be another important cause of increasing over-gathering practices. *P. peltolimba* is commercialized in regional markets in the Tehuacán Valley, which indicates its high demand, and the high risk of wild populations because of the absence of management practices (Arellanes et al., 2013), due to the difficulty to propagate it, which is the main reason to continue gathering it from the wild (Blancas et al., 2013). Nevertheless, the same species is under some kind of

management in the homegardens of Camotlán, Oaxaca (Pérez-Nicolas, Vibrans, & Romero-Manzanares, 2018), where its risk perception is different. Ixcatec people in Oaxaca gather *P. quadrifolia* from wild populations but also protect it leaving part of the plant in order for it to continue to grow and propagate. Some efforts have been done to propagate it ex situ, but “it does not like a different environment” (Rangel-Landa, Casas, Rivera-Lozoya, Torres-García, & Vallejo-Ramos, 2016; Rangel-Landa, Casas, García-Frapolli, & Lira, 2017). This human management, such as transplanting in

homegardens, is also reported for *P. auritum* (Browner, 1985; Blancas et al., 2013; Rangel-Landa et al., 2016), *P. sanctum* (Solis-Rojas, 2006), and *P. unguiculatum* (Geck, 2018). This variable information about different forms of management, and use intensity, stresses the need to develop studies focused on the evaluation of ecological parameters of wild populations of many of these species (density, microhabitat distribution), as well as to evaluate the effects of extraction from wild and to analyze the socioeconomic context of the localities where it occurs. In this study, *P. quadrangularis*, *P. auritum*, and *P. aff. uhdei* were recorded with high abundance in their wild populations, or at least in one of them. The rest of the species were recorded with scarce abundance. This evidence shows the relevance of forest management by the ethnic groups.

Even when some of the species are relevant in many ethnic and Mestizo groups because of their medicinal, food, or condiment uses, previous studies only reported one or few species (Arellanes et al., 2013; Blancas et al., 2013; Browner, 1985; Caballero, Cortés, Martínez-Alfaro, & Lira-Saade, 2004; Frei et al., 1998; Geck, 2018; Geck et al., 2016; Giovannini & Heinrich, 2009; Luna-José & Rendón-Aguilar, 2008; Salinas-Espinoza et al., 2017; Solis-Rojas, 2006), and they correspond to 19 of the 106 species (Villaseñor, 2016) reported for this state (Caballero et al., 2004; Frei et al., 1998; Geck, 2018; Geck et al., 2016; Giovannini & Heinrich, 2009; Luna-José & Rendón-Aguilar, 2012; Pérez-Nicolás et al., 2017, 2018; Rangel-Landa et al., 2016, 2017; Vergara-Rodríguez et al., 2017). Among these, the most mentioned is *P. auritum* and in minor proportion *P. peltolimba*; the rest of the species are named only once (Table 2). These previous studies were developed in eight ethnic groups, which is 50% of the total ethnic diversity of this state. In addition, few specimens in the consulted herbaria have ethnobotanical information, only *P. schiedeana*, *P. auritum*, and *P. amalago*, and *P. peltolimba*, *P. quadrifolia* and *P. rotundifolia*. Especially the genus *Peperomia* has been less collected in the state.

Hence, this study represents a first synthesis about traditional use in several municipalities of Oaxaca, with great ethnic representation. A similar ethnobotanical relevance of this plant family has been reported for the Ecuadorian Amazon, with seven species used for medicinal purposes (Caballero-Serrano et al., 2019).

Including our records and those reported in literature, 35 species and 6 affinities of Piperaceae have some use (Table 2). Compared with the 106 species recorded for Oaxaca (Fonseca & Samain, 2011), 33% of the species are used. However, given the aromatic and palatability properties of the family (a more conspicuous aspect in *Peperomia*, Figure 2(a)), it is to be expected that

additional species and uses will be recorded in future ethnobotanical expeditions.

The main uses of *Peperomia* and *Piper* species found in this study are as medicinal and edible plants. In the case of medicinal applications, this high richness of useful species is in accordance with those reported in literature for Mexico and for Oaxaca (Aguilar et al., 1994; Andrade-Cetto & Heinrich, 2005; Estrada-Reyes et al., 2013; Fournet et al., 1996; Frei et al., 1998; García et al., 2007; Geck, 2018; Geck et al., 2016; Giovannini & Heinrich, 2009; Mahiou et al., 1995; Martínez, 1969; Roersch, 2010; Schultes & Hofmann, 2000).

However, this is not the case for food or condiment uses, because only *P. peltolimba* (Arellanes et al., 2013; Pérez-Nicolás et al., 2018), *P. quadrifolia* (Rangel-Landa et al., 2016, 2017), and *P. hernandiifolia* (Luna-José & Rendón-Aguilar, 2012) are reported in literature, while in this study, we recorded five species.

Ceremony or ritual use is another well-represented category in this study, with six species. However, *P. amalago* and *P. unguiculatum* are the only species mentioned in the literature (Frei et al., 1998; Geck, 2018; Geck et al., 2016).

In the case of veterinary use, we added another record with *P. peltatum*, because the only species mentioned for this application in literature was *P. auritum* (Salinas-Espinoza et al., 2017).

Some species used in Oaxaca in at least one category are also reported in other countries, such as *P. aduncum*, whose record in the municipality of San Pedro Yólox (Table 1) to reduce bleeding caused by a cut, has also been observed in Cuba (Abreu, Sánchez, Pino, & Barreto, 2015) and Brazil (Vianna & Akisue, 1997). *P. umbellatum*, mentioned to alleviate stomachache in San Juan Yacé, has the same use in Nigeria (Ejele, Duru, Oze, Iwu, & Ogukwe, 2012), and its use to clean skin rash in Eloxochitlán de Flores Magón is similar to that given in Brazil, where it is applied for the treatment of skin lesions (Brohem et al., 2009). This consistency in the use of the same species in distant geographic localities indicates the soundness of traditional knowledge, as well as the empirical recognition of specific properties of plants. These evidences of patterns of knowledge and use of specific plant species to satisfy specific needs are every time more forceful (Caballero et al., 2004; Weckerle et al., 2012).

Based on the multivariate analysis, it was determined that there is no bias in species composition between voucher specimens of herbaria and our records in the study area. Moreover, it indicates that there are many regions of Oaxaca that have not been explored yet for the family.

This study also reinforces the previously reported pattern (Bernal-Ramírez et al., 2019; Rendón-Aguilar, Bernal-Ramírez, & Bravo-Aviles, 2017; Rendón-Aguilar,

Table 2. Useful species of Piperaceae in Oaxaca, Mexico at present. The contribution of the present study is indicated in bold. Cuicatec (Cui); Chinantec (Ch); Ixcatec (Ix); Mazatec (Ma); Mixtec (Mix); Nahuatl (Na); Zapotec (Za); Zoque (Zo). Condiment (Co); Food (F); Medicine (Me); Veterinary (Ve); Not indicated (ni).

Species reported in previous literature of Oaxaca	Reference	Ethnic group	Use	Species reported in the present study
Piper				
<i>Piper aduncum</i> L.	Solis-Rojas, 2006	Cui	ni	<i>P. aduncum</i> L.
<i>Piper amalago</i> L.	Frei et al., 1998	Za	Me, C	<i>P. amalago</i> L.
<i>Piper auritum</i> Kunth	Frei et al., 1998	Za	Me	<i>P. auritum</i> Kunth
<i>P. auritum</i>	Geck et al., 2016	Zo	Me	<i>Piper lapathifolium</i> (Kunth) Steud.
<i>P. auritum</i>	Geck, 2018	Zo	Me	<i>Piper peltatum</i> L.
<i>P. auritum</i>	Salinas-Espinoza et al., 2017	Mix	Ve	<i>Piper schiedeanum</i> Steud.
<i>P. auritum</i>	Browner, 1985	Ch	Me	<i>P. umbellatum</i> L.
<i>P. auritum</i>	Blancas et al., 2013	Na	F	<i>Piper aff. schiedeanum</i> Steud.
<i>P. auritum</i>	Rangel-Landa et al., 2016	Ix	F	
<i>P. auritum</i>	Pérez-Nicolás et al., 2017, 2018	Za	Me	
<i>Piper dioica</i> L.	Frei et al., 1998	Za	ni	<i>Piper aff. uhdei</i> C. DC.
<i>Piper hispidum</i> Sw.	Solis-Rojas, 2006	Cui	ni	
<i>Piper sanctum</i> (Miq.) Schtdl. ex C.DC.	Caballero y Cortés, 2004	NI	ni	
<i>P. sanctum</i>	Solis-Rojas, 2006	Cui	F	
<i>Piper scabrum</i> Lam.	Luna y Rendón, 2008	Za	Me	
<i>Piper tuberculatum</i> Jacq.	Frei et al., 1998	Za	Me	
<i>Piper unguiculatum</i> Ruiz y Pavon	Geck et al., 2016	Zo	Me, C	
	Geck, 2018	Zo	Me	
<i>Piper umbellatum</i> L.	Giovannini y Heinrich, 2009	Ma	Me	
	Luna y Rendón, 2008	Za	Me, F	
Previous records = 10				Records added = 5 (indicated in bold)
Peperomia				
<i>Peperomia campylotricha</i> Hill	Solis-Rojas, 2006	Cui	Me	<i>Peperomia alpina</i> (Sw.) A. Dietr.
<i>Peperomia donaguina</i> (C.) DC.	Solis-Rojas, 2006	Cui	ni	<i>Peperomia blanda</i> (Jacq.) Kunth
<i>Peperomia hernandiifolia</i> (Vahl) A. Dietr.	Luna y Rendón, 2008	Za	Me, Co	<i>Peperomia clavigera</i> Standl. & Steyererm.
<i>Peperomia nigropunctata</i> Miq.	Giovannini y Heinrich, 2009	Ma	Me	<i>P. hernandiifolia</i> (Vahl) A. Dietr.
<i>Peperomia peltimiba</i> C. DC. ex Trel	Arellanes et al., 2013	NI	F	<i>Peperomia leptophylla</i> Miq.
<i>P. peltimiba</i>	Blancas et al., 2013	Na	F	
<i>P. peltimiba</i>	Pérez-Nicolás et al., 2017, 2018	Za	Me	<i>Peperomia maculosa</i> (L.) Hook.
<i>Peperomia quadrifolia</i> (L.) Kunth	Rangel-Landa et al., 2016, 2017	Ix	F	<i>Peperomia obtusifolia</i> (L.) A. Dietr.
<i>Peperomia rotundifolia</i> (L.) Kunth	Giovannini y Heinrich, 2009	Ma	Me	
<i>Peperomia ubilicata</i> Ruiz y Pavon	Solis-Rojas, 2006	Cui	Me	<i>Peperomia pecuniifolia</i> Trel. & Standl
				<i>P. peltimiba</i> C. DC. ex Trel
				<i>Peperomia pseudoalpina</i> Trel.
				<i>Peperomia quadrangularis</i> (J. V. Thoms.) A. Dietr.
				<i>P. quadrifolia</i> (L.) Kunth

(continued)

Table 2. Continued.

Species reported in previous literature of Oaxaca	Reference	Ethnic group	Use	Species reported in the present study
				<i>P. rotundifolia</i> (L.) Kunth <i>Peperomia</i> aff. <i>blanda</i> (Jacq.) Kunth <i>Peperomia</i> aff. <i>glabella</i> (Sw.) A. Dietr. <i>Peperomia</i> aff. <i>glabra</i> C. DC. <i>Peperomia</i> aff. <i>leptophylla</i> Miq. Records added = 13 (indicated in bold)

Previous records = 8

Note. The contribution of this study is indicated in bold. Cuicatec (Cui); Chinantec (Ch); Ixcatec (Ix); Mazatec (Ma); Mixtec (Mix); Nahua (Na); Zapotec (Za); Zoque (Zo). Condiment (Co); Food (F); Medicine (Me); Veterinary (Ve); Not indicated (ni).

Bernal-Ramírez, Bravo-Avilez, & Mendoza-Ruiz, 2017) that there is a differentiated ethnobotanical knowledge and use of this family among ethnic groups, which is the case mainly for Chinantec and Zoque people for lowland and tropical species, as well as Mazatec and Zapotec people for species of temperate zones. This concordance among distribution of this family, traditional knowledge, and uses are basic aspects that reinforce the proposal that areas of higher biodiversity are related with ethnic groups (Pretty et al., 2009), and that they maintain and take care of the plant cover areas that provide them with the natural resources they rely on in their daily activities.

The traditional uses preserved and transmitted over the years have led to studies with scientific approaches of some species. In the case of *Peperomia*, these are focused on phytochemistry, pharmacology, ecology, phytopathology, germination, and plant physiology of few species such as *P. obtusifolia* (Alfieri & Knauss, 1973; Horner, 2012; Rivas et al., 2003; Strojny, 2000); *Peperomia blanda* (Jardim et al., 2015), and *P. rotundifolia* (Lans, 2006, 2007).

Scientific approaches are more numerous in *Piper* than in *Peperomia*, and in more species, such as *P. auritum* (Estrada-Reyes et al., 2013; Lepe & Jimenez, 1972; López-Barreiro, García-Hernández, Boucourt-Rodríguez, & Morejón-Rodríguez, 2014; Martínez-Padrón, Palmero-Álvarez, Gómez-Zayas, & Domínguez-Sardíñas, 2011), *P. aduncum* (Abreu et al., 2015; Da Silva et al., 2010; Kidd, 1996; Orjala, Erdelmeier, Wright, Rali, & Sticher, 1993; Rocha et al., 2011; Siges, 2005), *P. umbellatum* (Bidla, Titanji, El-Ghazali, Bolad, & Berzins, 2004; Bonaccorso, Winkelmann, Dumont, & Thibault, 2002; De Carvalho-Ricardo, Uieda, Fonseca, & Rossi, 2014; M. L. A. Hammer & Johns, 1993; Hartemink, 2002; Hiratsuka,

Toma, Diana, Hadriyanto, & Morikawa, 2006; Nghiem, Tan, & Corlett, 2015; Quimio & Quilario, 2007; Roersch, 2010), *P. amalago*, and *P. peltatum* (Da Silva et al., 2010; Sosa et al., 2002; Valadeau et al., 2009). These scientific studies also reinforce the traditional knowledge and value of this family.

Even when our ethnobotanical methodology consisted on an exploratory sampling technique, based on the selection by municipal authorities of local guides which are recognized as knowledgeable people within their community, there is no doubt that this article contributes to the record of traditional knowledge of this family in Oaxaca.

Ethnobotanical records of plants are a primary aspect of any ethnobotanical research. Basic information such as “which plants do you know,” “what are they used for,” “how do you use them,” and “how are they named” represents the starting point of future research, in order to answer specific questions about the traditional knowledge, uses, cultural value, and management of plant resources.

Implications for Conservation

Piperaceae is one of the 10 most species-rich botanical families in Oaxaca (García-Mendoza & Meave, 2011) and is also one of the most useful families in different ethnic groups in this state (Rendón-Aguilar, Bernal-Ramírez, & Bravo-Avilez, 2017; Rendón-Aguilar, Bernal-Ramírez, Bravo-Avilez, & Mendoza-Ruiz, 2017), as they satisfy daily needs. Because most of these plant resources are collected from wild populations, it is necessary to conserve forested areas in order to continue the access to these vegetal resources.

Some of them come from particular microenvironments (e.g., rocks, specific phorophytes, wet canyons)

and are conformed by small populations that, when drastically modified, could disappear. This is frequently observed in the different species of *Peperomia*, whose microhabitats are highly specific and habited by small populations. Even when some species have been propagated in home gardens, or traditional shade coffee plantations, many species can be found only in wild conditions, so an additional effort is needed in order to preserve natural populations, meaning that their habitat should also be preserved. Furthermore, the increased number of useful species registered for this family in this study suggests that more records could be added in future research. A notable aspect is that traditional knowledge is deep, persistent, and dynamic, and it currently has been recognized as a sustainable way to preserve these areas of high diversity in Oaxaca.

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Supplementary Material

Supplementary material for this article is available online.

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