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Comparison of traditional knowledge about edible plants among young Southern Tepehuans of Durango, Mexico

Comparación de conocimientos tradicionales sobre plantas comestibles entre jóvenes Tepehuanes del Sur de Durango, México

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Abstract

Background: Traditional ecological knowledge is an important part of biocultural heritage of societies; it has been reported their disappearance and in some cases this phenomenon has been associated with socioeconomic factors such as formal education.

Questions and/or Hypotheses: How does traditional knowledge about edible plants vary between three groups of young Southern Tepehuans from different educational contexts?

Study site and dates: Southern Durango, Mexico; September 2017 to November 2018.

Methods: Traditional knowledge was compared among young Southern Tepehuan informants from three educational contexts: rural students, urban students and non-students. Each informant answered a questionnaire about 20 selected wild edible plants and wrote a free list of additional species. The results of these instruments allowed to determine a traditional knowledge grade per person. The statistical analyzes performed were ANCOVA and Chi-square tests.

Results: Educational context, as well as age and gender proved to be variables statistically significant, not so the interaction between educational context and gender. Non-students hold the highest knowledge grade, and no significant difference was found in the traditional knowledge among rural and urban students.

Conclusions: As has been documented in studies for other ethnic groups, our results suggest that traditional knowledge tends to disappear among Southern Tepehuans due to changes in lifestyles induced by formal education, such as reduced access to nature, nutritional transition and disuse of indigenous languages. To preserve the biocultural heritage, it is essential to apply novel strategies favoring alternative ways of knowledge transmission.

Keywords: Cultural erosion, *O'dam*, Sierra Madre Occidental, traditional ecological knowledge.

Resumen

Antecedentes: El conocimiento ecológico tradicional es parte importante del patrimonio biocultural de las sociedades; algunos reportes de su desaparición se han asociado a la educación formal.

Preguntas y/o hipótesis: ¿Cómo varía el conocimiento tradicional sobre plantas comestibles entre tres grupos de jóvenes Tepehuanes del Sur de diferentes contextos educativos?

Lugar y fechas del estudio: Sur de Durango, México; septiembre 2017 a noviembre 2018.

Métodos: Se comparó el conocimiento tradicional entre jóvenes Tepehuanes del Sur de tres contextos educativos: estudiantes rurales, estudiantes urbanos y no estudiantes. Cada informante respondió un cuestionario sobre 20 plantas comestibles silvestres seleccionadas y escribió un listado libre de especies adicionales. Los resultados de estos instrumentos permitieron estimar un grado de conocimiento tradicional por persona. Los análisis estadísticos realizados fueron ANCOVA y pruebas de Chi-cuadrada.

Resultados: el contexto educativo, la edad y el género resultaron ser variables estadísticamente significativas, no así la interacción entre contexto educativo y género. Los no estudiantes tienen el grado de conocimiento más alto y no se encontraron diferencias significativas en el conocimiento tradicional entre los estudiantes rurales y urbanos.

Conclusiones: Como se ha documentado para otros grupos étnicos, los resultados de este estudio sugieren que el conocimiento tradicional tiende a desaparecer debido a cambios en los estilos de vida inducidos por la educación formal, como el acceso reducido a la naturaleza, la transición nutricional y el desuso de las lenguas indígenas. Para preservar el patrimonio biocultural, es fundamental aplicar estrategias que favorezcan vías alternas de transmisión del conocimiento.

Palabras clave: Conocimiento ecológico tradicional, erosión cultural, *O'dam*, Sierra Madre Occidental.

Traditional knowledge about biodiversity is the result of a long process of interactions between humanity and the environment, the origin of which is the interest in knowing nature and satisfying subsistence needs (Toledo & Barrera-Bassols 2008). This type of knowledge, also called traditional ecological knowledge (TEK), is characterized by being accumulative and changing through adaptation processes, while it is transmitted from generation to generation (Berkes *et al.* 2000).

The development of TEK over time in different regions and cultures has given rise to the biocultural heritage of each society or region. This involves both the use and management of species and ecosystems, including agrobiodiversity; as well as the role and interpretation of nature within cultural aspects such as worldviews, religiosity, and symbolism (Boege 2008, Sánchez-Álvarez 2012).

TEK is an important part of the cultural identity of indigenous peoples and local communities; currently, it is also considered the basis of strategies for the conservation and sustainable management of biodiversity (Casas *et al.* 2016, Ban *et al.* 2018). This perspective becomes very important in megadiverse countries (Boege 2008, Toledo & Barrera-Bassols 2008) such as Mexico.

Regrettably, the disappearance of biocultural heritage in different societies has been reported and associated with socioeconomic factors derived from the globalization process (Ramirez 2007, Toledo & Barrera-Bassols 2008). Among these cultural erosion factors stand out: the expansion of urban areas and deforestation (Monroy & Ayala 2003, Barreau *et al.* 2016); the change from a traditional to industrialized agriculture (García-Hilario *et al.* 2016); migration to urban areas (Nguyen 2003); the integration into economic activities not related to nature (Reyes-García *et al.* 2007, Saynes-Vásquez *et al.* 2013); formal education (Wester & Yongvanit 1995, Zent 2001, Voeks & Leony 2004, Reyes-García *et al.* 2010, Bruyere *et al.* 2016); and the disuse of indigenous languages (Benz *et al.* 2000, Zent 2001).

Faced with these scenarios that favor the loss and homogenization of TEK, its conservation and revitalization has been part of the objectives set out in different international forums and policies, such as the Convention on Biological Diversity (United Nations 1992) and the United Nations Declaration on the Rights of Indigenous Peoples (United Nations 2007). Ethnobiological studies could contribute to this conservation and revitalization of TEK, however, this kind of studies frequently focus on older people (Pardo-de Santayana *et al.* 2005, Ramirez 2007) or in specialists in traditional activities, for instance healers (Ramos-Hernández *et al.* 2007), which may create a lack of information about the dynamics and permanence of TEK in other sectors of society such as youth. In Mexico there are few studies referring to ethnobotany in the northern states of the country and even less focused on the processes of TEK transmission dynamics, intracultural variation and its cultural erosion among young people with and without formal education (cultural ethnobotany). According to Camou-Guerrero *et al.* (2016), between the years 1960 and 2010, ethnobotanical studies have been carried out for 40 of the more than 60 indigenous groups in the country, but more than 50 % of all studies are concentrated in only six groups from the central-south region. Likewise, it is reported that the main focus of these studies has been descriptive ethnobotany, which includes the creation of plants inventories, along with their uses and vernacular names. Therefore, it is worth to carry out cultural ethnobotanical studies on both TEK loss and focused on young people.

Southern Tepehuan and the Mexican biocultural heritage. Mexico has a vast biocultural heritage (Boege 2008), which is related both with its status as a megadiverse country (Toledo & Barrera-Bassols 2008) and with the presence of more than 62 ethnolinguistic groups (Navarrete-Linares 2008). An example of this biocultural richness is the record of 7,461 useful vascular plant species (Mapes & Basurto 2016), 32 % of the known taxa in the country according to Ulloa-Ulloa *et al.* (2017).

This biological and cultural richness is well represented in the state of Durango and adjacent areas. Vascular plants in Durango represent more than 20 % of the total reported by Villaseñor (2016) for the entire country, being the Sierra Madre Occidental (SMO) the region with the greatest species richness. Further, the southern extreme of Durango, as well as the adjacent areas of other states, has been recognized as an area with a high degree of endemism in vascular plants (González-Elizondo 1997). It is also an important cultural region, in which four indigenous groups inhabit: Coras, Huicholes, Mexicaneros and Southern Tepehuan (ST).

There are a few studies that point out the importance of traditional knowledge that ST have about biodiversity and its uses to solve basic subsistence issues, such as food and health (Sánchez-Olmedo 1980, González-Elizondo *et al.* 2001, 2004, Reyes-Valdez 2007). ST eat at least 14 species of fungi (González-Elizondo 1991); 12 *Agave* species are used as food, medicine, mezcal preparation, fiber extraction, among other uses (González-Elizondo &

Galván 1992); 122 wild vascular plant species are used as food (Narváez-Elizondo *et al.* 2020); 158 for health care purposes (González-Elizondo & González-Elizondo 1994) and some others are employed to make handicrafts and other useful objects (González-Elizondo *et al.* 2017).

These advances in the knowledge of the ST ethnoflora, are fundamental tools to address ethnobotanical research along with other approaches, such as anthropological or ecological, as well as inter and transdisciplinary studies oriented to the sustainable use of the biocultural heritage of Mexico. A major issue to be addressed is change and loss of TEK intergenerationally due to factors associated with globalization. Therefore, the objective of this research was to analyze the current state of traditional knowledge about edible plants among young ST people, evaluating the hypothesis that there are intracultural differences in this type of knowledge, associated with socioeconomic factors such as formal and informal education.

Materials and methods

Study Area. ST live in hundreds of scattered settlements organized in seven ancestral, socially and politically independent communities, each one composed of a religious and political center, several medium to large settlements (*anexos*) and a large number of small settlements.

The territory inhabited by ST is among the largest (9,380 km^2) and rugged areas occupied by indigenous peoples in Mexico; it is mainly in Durango state with a few settlements in the states of Zacatecas and Nayarit. Two landscape units (ecoregions) of the SMO are present: Madrean and Tropical (González-Elizondo *et al.* 2012); the first generally above 2,000 m, with temperate and semi-cold climates, and mostly pine and pine-oak forest; the later enters the SMO through the deep canyons on the western flanks, where the elevation ranges from 540 to 2,200 m (Figure 1).

Data collection. The field work was carried out from September 2017 to November 2018. We worked with 162 young Tepehuan informants from three different educational contexts: 1) Rural students (with formal education received within their communities (Figure 2); both high school and undergraduate, all of them studying in La Guajolota settlement); 2) Urban students (with formal education; high school and higher education, received outside their communities in an urban context, in various school centers in Durango city); 3) Non students (young people dedicated exclusively to field activities such as agriculture, within their communities). The interviews and the questionaries were conducted in Spanish, always with the company of an *O'dam* translator who helped with details about Tepehuan terminology.

Each informant provided personal data (name, age, community of origin and current grade or school situation); answered a ten questions questionnaire (Table 1) about 20 selected species of wild edible plants of the ST ethnoflora. The species selection criteria were: to represent different environments in the region and, according to previous field studies, to include some which TEK seems to be well spreading among people as well as some species previously recorded based on one or a few informants (Table 2). These were shown to informants using a catalog with images of each species. Once the ten questions per plant section was complete, we asked each informant to write a free list of other edible plants of the region that they knew of.

Taxonomic identification of the species mentioned, by common name, in the free-list instrument, was done combining two main procedures: 1) search for the common local names in the CIIDIR herbarium database, and 2) key informant interviews and botanical collections with their participation, specifically aimed at finding the listed species. Plants collected were processed through conventional techniques, identified using specialized literature and deposited at CIIDIR herbarium.

Data analysis. Based on answers to six questions (1, 2, 3, 4, 5 and 9) about each of the 20 plants of the visual catalog, plus those of the free list of each informant, a traditional knowledge grade per person was determined. This grade was calculated from the sum of one point for each correct answer, the "correctness" based on the ethnobotanical and ecological information on each species available in the CIIDIR Herbarium database and in previous ethnobotanical studies. To analyze how the degree of traditional knowledge varies depending on the socioeconomic characteristics of the informants, using the STATISTICA 7 software, an analysis of covariance (ANCOVA) was carried out; with a significance level of 95 % ($\alpha = 0.05$) and taking the traditional knowledge grade as the dependent variable, age as a covariate, and the educational context and gender as factors. The residuals were previously calculated and based on these, the assumptions of normality and homoscedasticity of the variances were confirmed through the Kolmogorov-Smirnov ($P > 0.05$) and Levene ($P > 0.05$) tests respectively. Also, a Tukey test ($\alpha = 0.05$) was performed to determine which means differ among the factors.

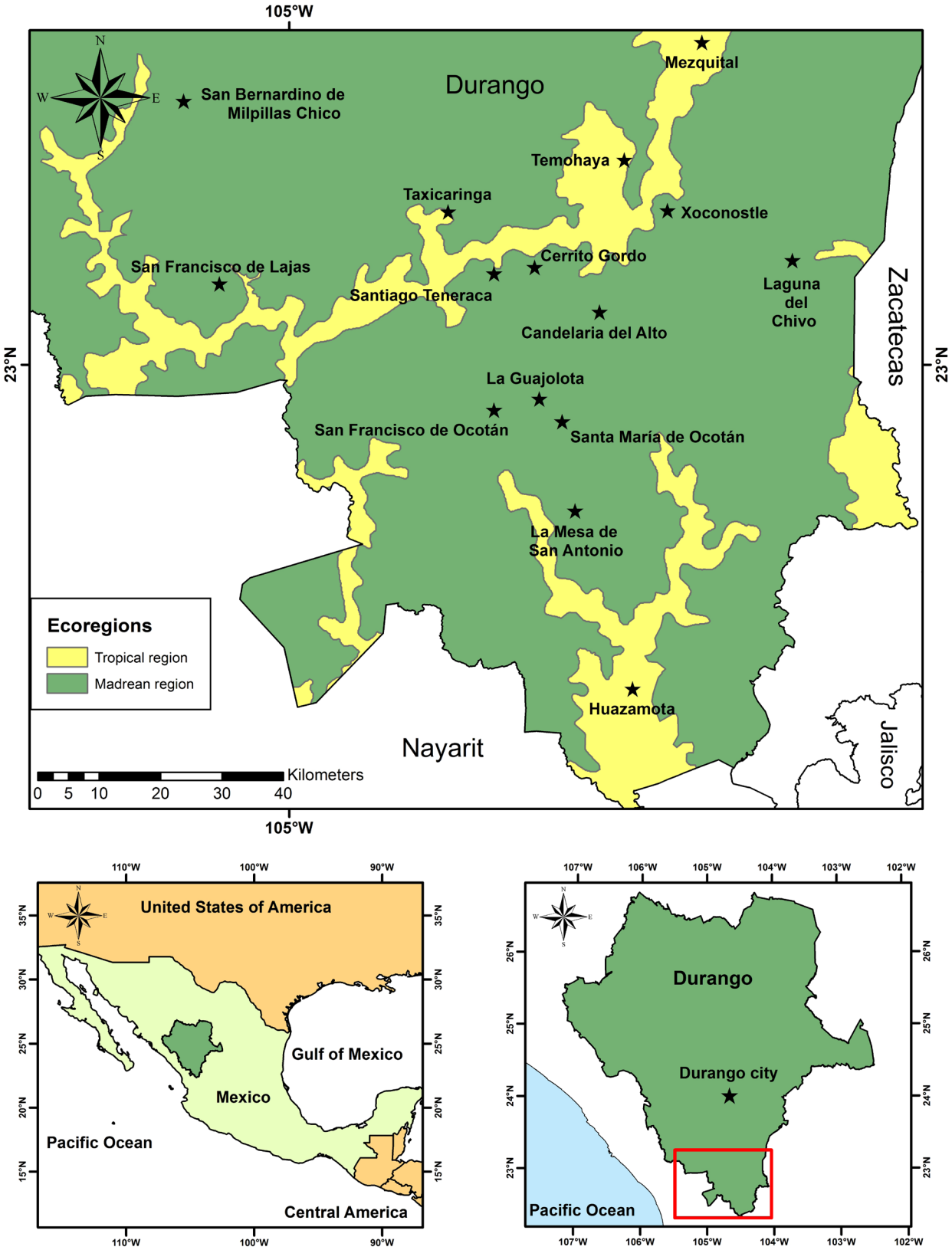

Figure 1. Southern Tepehuan territory in Durango, Mexico.

Moreover, homogeneity group Chi-square tests ($\alpha = 0.05$) were carried out for answers to questions 2, 7 and 8, to analyze whether there is an association between the educational contexts and: 1) the knowledge of the Tepehuan names of the plants; 2) a positive perception of the consumption of each plant; 3) the knowledge of the season in which each plant can be used for edible purposes.

Answers to questions 6 and 10 were recorded and analyzed only through percentages, being useful to know aspects such as the form of consumption, as well as anecdotes or comments to know some aspects about the dynamics of the cultural transmission of traditional knowledge, which were classified according to the three categories proposed by Hewlett & Cavalli-Sforza (1986): vertical, horizontal and oblique transmission.

Results

Informants. A total of 162 people in an age range of 15 to 30 years participated as informants in this study. According to the three educational contexts considered, they were distributed as follows: rural students (n = 83; 32 men and 51 women; mean age: 18 years old); urban students (n = 46; 22 men and 24 women; mean age: 17 years old); and non-students (n = 33; 15 men and 18 women; mean age: 22 years old).

Comparison of traditional knowledge grade. The ANCOVA analysis indicate that the variables age ($F_{1, 155}$ = 23.73, P = 0.000003), gender ($F_{1, 155}$ = 5.06, P = 0.025756) and educational context ($F_{2, 155}$ = 8.84, P = 0.000231) were statistically significant; not so the interaction between the educational context and gender ($F_{2, 155}$ = 1.98, P = 0.141267). Moreover, a Tukey test found that the traditional knowledge grade between rural students ($\bar{x}$ = 49.434) and urban students ($\bar{x}$ = 44.152) does not present statistically significant differences, in contrast with non-students, whom had a higher level of knowledge ($\bar{x}$ = 69.765) (Figure 3); in addition, women ($\bar{x}$ = 53.827) had a higher traditional knowledge grade than men ($\bar{x}$ = 49.376).

Knowledge about plant names in Tepehuan language. Answers to question 2, based on the Chi-square test, show significant differences between the three groups of youngsters with respect to the knowledge of common names in Tepehuan for 13 of the 20 visual catalog species (Supplementary material Table S1). No significant differences were found for seven species: *Agave shrevei*, *Agave vilmoriniana*, *Arctostaphylos pungens*, *Leucaena leucocephala*, *Prosopis laevigata*, *Sinclairia palmeri* and *Tigridia multiflora*. For the taxa that did differ, the group of non-students cited the Tepehuan common names of most of the species in a higher percentage, except for those of *Dahlia coccinea* and *Begonia tapatia*, cited in a higher proportion by rural and urban students respectively.

Form of consumption. The percentage of informants who showed knowledge about the form of consumption was higher among non-students for 19 of the 20 plants included in the visual catalog (except for *Agave vilmoriniana*), followed by the group of rural students (Figure 4). The forms of consumption of five species (*Arctostaphylos pungens*, *Leucaena leucocephala*, *Lippia graveolens*, *Prunus serotina* and *Stenocereus queretaroensis*) were cited by 100 %

Table 1. Questionnaire on 20 selected plants applied to informants.

No.	Question
1	Do you know this plant? (yes/no)
2	Tepehuan common name
3	Spanish common name
4	Is this edible? (yes/no)
5	What part of the plant is edible?
6	Is it eaten raw or is it prepared in some way?
7	Do you like to eat this? (yes/no/I have not tasted it) - why?
8	In what season of the year can you get it? A) *taabhak* (December-May), B) *ti'ngiak* (June-September), C) *tómok* (October-November), D) all year
9	Where does it grow? A) in cool areas with oak and pine forests (*jukgam*), B) in warm land (*taatsab*), C) cultivated fields, D) houses or roads, E) on the banks of rivers, F) other
10	How did you learn what you know about this plant?

Figure 2. Some students of the Technological University of Mezquital and the first author during the fieldwork in Santa María de Ocotán, Durango.

of the group of non-students, while there were reported by 63.9 to 90.4 % of rural students and by 20.5 to 48 % of urban students (Supplementary material Table S2). On the other hand, the plants whose form of consumption was less known were: *Salvia hispanica*, *Tigridia multiflora* and *Tripsacum dactyloides*; the first and the last were only cited by very few informants of the non-students group.

Perception about the consumption of each plant (Do you like to eat this?). Statistically significant differences were found about the perception of consumption for 17 of the 20 plants included in the visual catalog; being the group of non-student informants the one with the highest percentage of people with a positive perception of plant consumption (Supplementary material Table S3). The three species in which no significant consumption perception difference was found were *Agave shrevei* and *Arctostaphylos pungens*, with high, and *Agave vilmoriniana* with low positive perception by the three groups.

Knowledge about season of availability of each plant. Regarding question 8 (In what season of the year can you get it?) there are statistically significant differences in the knowledge of the three groups about the availability of edible parts of the plants through seasons of the year for 16 of the 20 species, with non-students group knowing better about the seasons for 14 of those (Supplementary material Table S4). No significant differences were found for *Agave vilmoriniana*, *Arctostaphylos pungens*, *Prosopis laevigata* and *Tripsacum dactyloides*.

Dynamics of the cultural transmission of traditional knowledge. Regarding question 10, a high percentage of responses referring to the vertical transmission of traditional knowledge were recorded in the three groups (Supplementary material Table S5), except for *Stenocereus queretaroensis* and *Lippia graveolens* in the case of non-students; for the first, a high proportion of people gave responses allusive to oblique transmission (78.7 %), while for the latter, both oblique and vertical transmission resulted in equal percentages.

Knowledge about other edible plants (free listings). Once the free listings provided by each of the 162 informants were compiled and analyzed, a general list composed by a total of 57 taxa was obtained. Particular free listings for each of the three informant groups included 42, 31 and 34 taxa for non-students, rural students and urban students, respectively (Supplementary material Table S6). The general free list includes 48 plants, 7 fungi, 1 insect and 1 indeterminate taxon.

Discussion

Comparison of knowledge among educational contexts. The results of this study indicate that the group of non-

Table 2. List of the 20 plant species shown to informants in a visual catalog, of which they answered 10 questions.

Catalog number	Taxa
1	*Agave shrevei* Gentry
2	*Agave vilmoriniana* A. Berger
3	*Arctostaphylos pungens* Kunth
4	*Begonia tapatia* Burt-Utley & McVaugh
5	*Brosimum alicastrum* Sw.
6	*Chenopodium album* L.
7	*Dahlia coccinea* Cav.
8	*Ferocactus histrix* (DC.) G.E. Linds.
9	*Leucaena leucocephala* (Lam.) de Wit
10	*Lippia graveolens* Kunth
11	*Oxalis hernandezii* DC.
12	*Prosopis laevigata* (Humb. & Bonpl. ex Willd.) M.C. Johnst.
13	*Prunus serotina* Ehrh.
14	*Salvia hispanica* L.
15	*Sinclairia palmeri* (A. Gray) B.L. Turner
16	*Stenocereus queretaroensis* (F.A.C. Weber) Buxb.
17	*Tagetes lucida* Cav.
18	*Tauschia nudicaulis* Schltdl.
19	*Tigridia multiflora* (Herb.) Ravenna
20	*Tripsacum dactyloides* (L.) L.

students, youngsters engaged in field activities, has a higher traditional knowledge about edible plants than students, both rural and urban (Figure 3). These results are consistent with other studies that find that TEK has a negative association with socioeconomic factors such as formal education. The main explanations for this fact are: 1) the decrease in the time that students spend in the field to handle academic activities and, consequently, the decrease in learning from nature; and 2) the marginalization of content related to TEK in educational curricula (Wester & Yongvanit 1995, Sternberg *et al.* 2001, Zent 2001, Voeks & Leony 2004, Quinlan & Quinlan 2007, Srithi *et al.* 2009, Reyes-García *et al.* 2010, Saynes-Vásquez *et al.* 2013, Bruyere *et al.* 2016).

It is notorious the lack of statistically significant difference in the grade of traditional knowledge between rural and urban students. It was expected that the former would have a higher grade of traditional knowledge, since they live in an environment where these wild edible plants are available. Urban students, on the other hand, are immersed in an environment where deforestation and loss of biodiversity negatively impact the transmission of TEK (Monroy & Ayala 2003, Barreau *et al.* 2016). The unexpected similarity in the grade of knowledge among the two student groups may be related to the fact that ST diet has incorporated in recent years a considerable number of industrialized foods that have displaced the traditional ones (Reyes-Valdez 2007).

Regarding the knowledge about the plant names in Tepehuan language, significant differences were found for 13 of the 20 plants in the visual catalog, 11 of which were cited in a higher proportion among the non-students

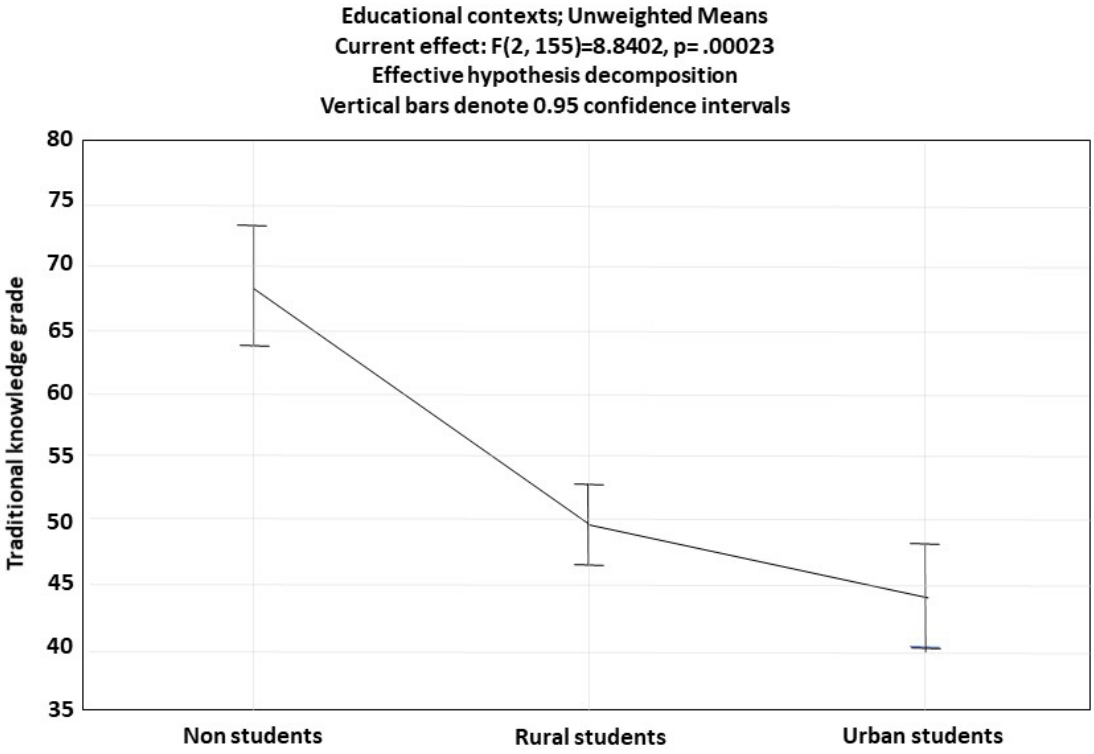

Figure 3. Comparison of traditional knowledge grade between three educational contexts of Southern Tepehuan informants.

(Table S1). The other two groups of youngsters spend less time in nature and thus, know less about it. Berlin (1972) points out that words of the traditional classifications on biodiversity disappear when activities related to the environment decline. There was no statistically significant difference in the knowledge of seven of the 20 plants among the three groups, in three cases (*Arctostaphylos pungens*, *Agave shrevei* and *Leucaena leucocephala*) it obeys to the fact that such plants are widely known among all the informants; for the other four species, there is a general lack of knowledge, and less than 50 % of the informants in all groups was able to cite the Tepehuan plant names. Among the species for which the knowledge differs significantly among the groups, the less known are *Salvia hispanica* and *Tripsacum dactyloides*, cited by less than 30 % of people in each group. Interestingly, *Salvia hispanica*, a sage, was highly appreciated in antique Mesoamerican cultures and is at present recognized as a promising food in Mexico and the European Union (Muñoz *et al.* 2013, Xingú-López *et al.* 2017). Lack of knowledge about it among ST may be related to the fact that it is scarce in the wild, where it may be a relic of old crops now in disuse in the Tepehuan zone (Narváez-Elizondo *et al.* 2020).

According to the linguistic research of Torres-Sánchez (2018), Tepehuan children of Santa María de Ocotán begin to stay in contact with the Spanish language early, when they enter school and, as they keep studying, the use of Spanish becomes more frequent than Tepehuan for them.

The educational curricula are carried out almost entirely in Spanish; additionally, there are some teachers that do not speak Tepehuan; this situation is accentuated in the case of students living in the city of Durango, even more immersed in mestizo culture. Furthermore, younger generations use Tepehuan and Spanish interchangeably in different situations, which could lead to a state of balanced bilingualism or Tepehuan may be displaced by Spanish. These scenarios documented by Torres-Sánchez (2018) can partially explain the low knowledge of the Tepehuan names of some plants of the visual catalog, and even the low grade of traditional knowledge about edible plants among the rural and urban students. Some other studies indicate that the loss or disuse of indigenous languages is associated to the decrease in traditional knowledge about biodiversity (Benz *et al.* 2000, Zent 2001, Martínez-López *et al.* 2016).

Another aspect to highlight is the greater knowledge of non-students about the form of consumption as well as the seasons of the year in which the edible parts of most

plants can be obtained (Tables S2 and S4). An explanation for this is the fact that these youngers are engaged in activities of the primary economic sector (agriculture, extraction of forest resources, etc.), as has been also found in other studies (Reyes-García *et al.* 2007, Saynes-Vásquez *et al.* 2013). It should be mentioned that the consumption of wild plants, mainly those consumed raw, is common during activities related to nature (Pardo-de Santayana *et al.* 2005, Maseko *et al.* 2017); while plants that involve preparation prior to its consumption, can be collected in the field to be eaten after work or stored to be available even in later times, through processes as drying (Peredo & Barrera 2017), as is frequently the case among ST for *Lippia graveolens* and *Tagetes lucida*.

The lack of knowledge about the harvest season of wild plants may represent a problem related to food security issues. Some studies have documented the importance of wild plants as complement or substitutes of other foods in the face of shortages during social conflicts (Caballero & Mapes 1985, Tardío *et al.* 2006, Theien 2009, Redžić 2010, Vorstenbosch *et al.* 2017) or due to climatic issues (Laferrière 1992).

Comparison of knowledge by age. The group of non-students with the highest mean age (22 years old) turned out to hold the highest traditional knowledge grade, suggesting that age may influence TEK, despite the narrow age range of this study (15-30 years old). A positive association between age and TEK has been found in studies with broader age ranges, *e.g.*, that of Bortolotto *et al.* (2015) who worked with a range of 21-86 years old. However, there are also reports of a null association between age and TEK (Arango-Caro 2004, Martínez-López *et al.* 2016), and therefore the effects of other socioeconomic factors must be considered together with age to explain the ethnobotanical phenomena of each society. It is important to note that the three study groups in our work were within an age range that, according to some authors (Zent 2001, Case *et al.* 2005) corresponds to part of a very important phase of TEK learning, which begins from childhood and can culminate between 18-30 years old. So, exposure to the factors negatively associated with traditional knowledge as those discussed above, could induce additional processes of cultural erosion on other aspects linked to the useful flora.

Knowledge grade by gender. It was found that women have a greater traditional knowledge on edible plants than men. This coincides with reports in other regions, *e.g.*, Salento, Colombia (Arango-Caro 2004), Boboye, Niger (Dan Guimbo *et al.* 2011), and El Jadida, Morocco (Tbatou *et al.* 2016). It should be mentioned that this does not necessarily reflects a constant pattern, since some studies report not finding differences about the knowledge of this kind of food resources between men and women (Camou-Guerrero *et al.* 2008, Bortolotto *et al.* 2015); or even, in some others, a greater knowledge among men is reported (Kujawska & Łuczaj 2015, Pío-León *et al.* 2017). The pattern found among young ST can be explained through gender role differences in domestic activities, as food preparation is a task carried out largely by women, especially during some traditional ceremonies (Cramaussel 2013).

Perception of wild plants consumption. The perception of the consumption of wild plants was significantly different by educational context for 17 of the 20 plants considered. The non-students group shows the highest tendency towards a positive perception of plant consumption. Good taste was the main reason associated with a positive perception for all taxa in the three informant groups. This is important if we consider what has been pointed out in other studies (Sõukand 2016, Thakur *et al.* 2017), in which factors such as taste and good aromas are reasons that encourage the consumption of wild edible plants, contributing to the conservation of this type of biocultural heritage.

Transmission of traditional knowledge. Concerning the forms of transmission of traditional knowledge for each plant, vertical transmission was recorded in a higher percentage into the three groups of informants for most plants, except for *Stenocereus queretaroensis* and *Lippia graveolens* among the non-students, who commented on oblique transmission for the first, and oblique and vertical transmission for the second plant. Generally, a higher frequency of vertical transmission coincides with other studies that indicate the importance of parents and grandparents as the main diffusers of knowledge about wild edible plants (Yates & Ramírez-Sosa 2004, Eyssartier *et al.* 2008, Mosquera-Mena *et al.* 2015, Ochoa & Ladio 2015). It is worth mentioning that this form of transmission of traditional knowledge is considered the most conservative, and very few innovations occur in this type of knowledge when it is presented alone or in a dominant way (Cavalli-Sforza & Feldman 1981, Hewlett & Cavalli-Sforza 1986).

The importance of the oblique transmission on the knowledge of *Stenocereus queretaroensis* and *Lippia graveolens* for non-students, can be related to the fact that the collection of their fruits and leaves, respectively, are

important economic activities for the inhabitants of the ST region. Therefore, youngsters may be learning aspects of these plants, either through people who market them or even during the same collection work, interacting with other people. Similar results have been found in cases such as that of a medicinal plant market in Tanzania, in which vendors exchange TEK with each other (McMillen 2012); or among Austrian migrants in Australia, Brazil and Peru, who by working as chefs in restaurants or as kitchen instructors, transmit knowledge about food to other people, which they previously learned through vertical transmission (Haselmair *et al.* 2014). According to Cavalli-Sforza & Feldman (1981) and Hewlett & Cavalli-Sforza (1986), oblique transmission, which involves agents external to the family, mainly when it occurs from one person to a group, is an efficient communication process where knowledge can begin to show greater variation in less time, since it is spread intergenerationally.

Knowledge about other edible plants shown in free listings. Non-students provided the most extensive list of edible taxa (74 % of the total), followed by urban students (60 %) and, finally, rural students (54 %). It is important to note that, even though during the information gathering, participants were asked to provide information about uncultivated edible plants, in all three study groups, there were some informants who gave data regarding cultivated plants, as well as on fungi, and even on an insect. This may be related to the fact that some people do not distinguish the differences between fungi and plants, being fungi one of the most appreciated edible wild resources by ST during the rainy season (González-Elizondo 1991). Further, the three informant groups mention *jocolish*, a wild edible resource related with an insect (family Cynipidae) that induces the development of galls on oaks (*Quercus* spp.) as part of their life cycle, and are precisely these galls the edible structures, therefore associated as part of these trees.

Of the total of 57 taxa included in the general free list (Table S6), 17 (30 %) are cultivated species. Four of them (*Amaranthus* sp., *Cucurbita* sp., *Cucurbita ficifolia* and *Zea mays*) are traditional crops that have been used by ST since pre-Hispanic times (González-Elizondo *et al.* 2017). The other 13 correspond to plants that are traded or cultivated on a small scale and can also be considered exotic in the Tepehuan territory. Although the report of exotic plants is usually related to a process of cultural erosion, these taxa were considered to calculate the traditional knowledge grade of each informant since, according to Albuquerque (2006), this situation could also be interpreted under the hypothesis of diversification, which propose that the stock of traditional knowledge about useful flora is enriched by the incorporation of exotic species. A comparative study is necessary on aspects such as the frequency of use and the proportion of useful native and exotic species among the ST to thoroughly analyze possible processes of cultural erosion or scenarios such as that proposed by the diversification hypothesis.

According to the frequency of mentions of each taxon included in the free list, the most important for each group are as follows: for non-students, *Opuntia* sp. and *Valeriana pratensis* (36 % each), *Pithecellobium dulce* and *Spondias purpurea* (30 % each), and *Amanita basii* (21 %); for rural students, *Amanita basii* (30 %), Cynipidae galls (25 %), and *Opuntia* sp. (19 %); while for urban students, *Opuntia* sp. (43 %), Cynipidae galls (24 %), and *Spondias purpurea* (13 %). The presence of *Amanita basii* and *Opuntia* sp. in the free list of the three informant groups is notorious; the former, as mentioned above, is one of the most appreciated food resources during the rainy season, while from the latter are eaten both the fruit and the tender stem or cladode, which is consumed plain, as a side vegetable or as an ingredient of various stews, mainly before the rainy season. The mention by informants of the three groups of an unidentified ethnotaxon called *sombiadam*, is a detail that indicates that it is worth continuing with ethnobotanical studies in the area to rescue TEK not yet documented.

Opportunities for revitalizing traditional knowledge. Education is a human right closely linked to well-being. However, it has also been documented that it may induce a trend towards the homogenization and disappearance of some components of cultural diversity throughout the world, by imposing visions and practices from the Western culture above local customs and knowledge (Aikman 1999, Bensasson 2013, Hickling-Hudson & Ahlquist 2003). As mentioned previously, a process of cultural erosion of the TEK may be occurring in all three groups of informants, but particularly on those exposed to formal education.

A possible solution to this is the implementation and strengthening of intercultural education, which should include content related to TEK in academic activities and programs. For example, some studies have documented that people of different ages who had received or were taking educational programs with contextualized material in their indigenous languages, and whose teachers belonged to the same ethnic groups (who better understood their culture), had a higher TEK compared to people whose ed-

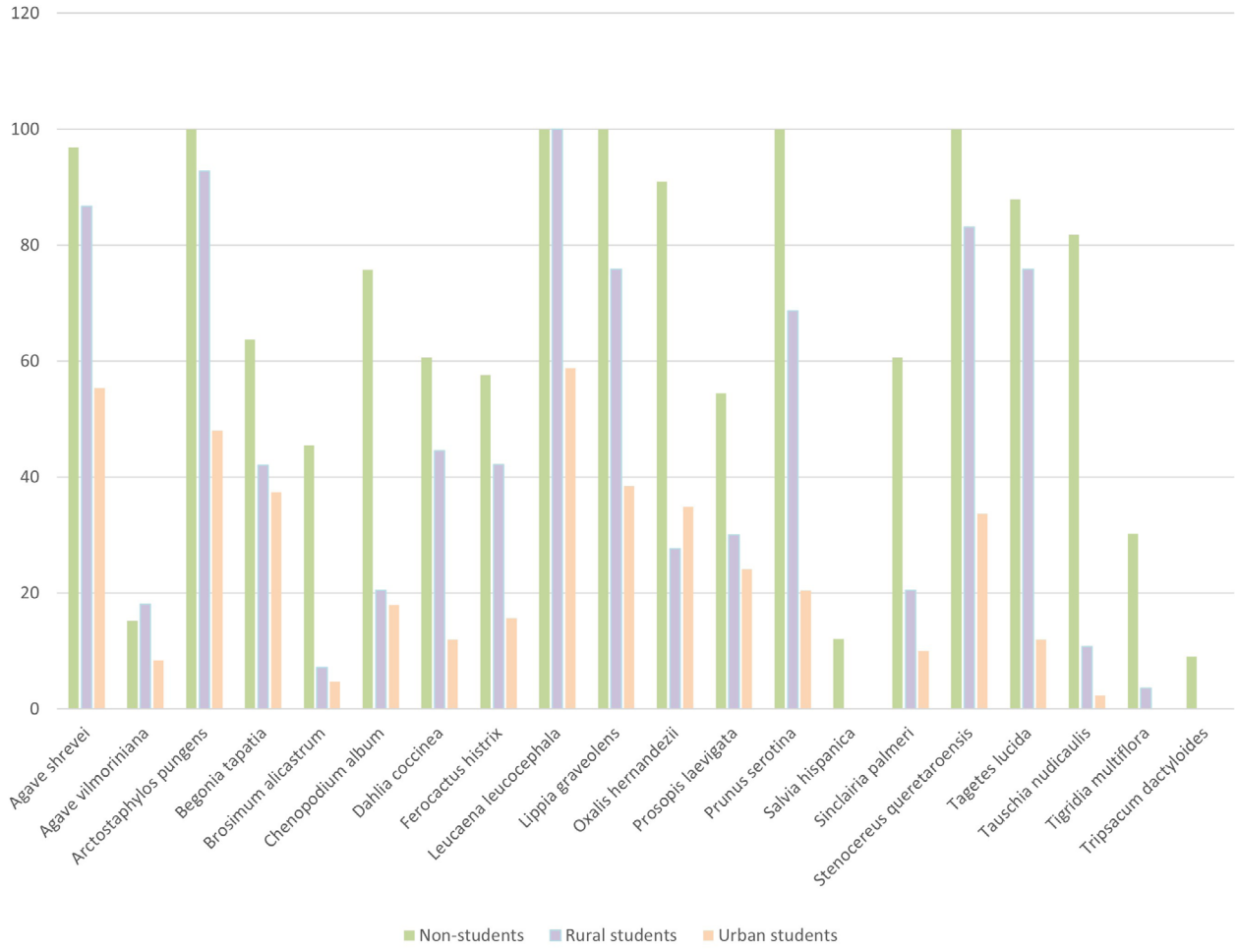

Figure 4. Comparison of the percentage of informants from the three educational context groups that cited traditional knowledge about the form of consumption of 20 plants.

ucational system did not have these particularities (Reyes-García *et al.* 2010, Wyndham 2010). In this sense, it is worth noting the observations reported by Torres-Sánchez (2018), about a greater influence of the Spanish language as Tepehuan students advances and concludes their academic formation within their territory.

Although formal education contextualized according to each local culture helps to transmit TEK, some of its elements, such as practical knowledge, may continue to be affected, since they are often learned outside the classrooms, unlike other theoretical issues (for instance: names of plants) (Reyes-García *et al.* 2010). Therefore, in addition to the theoretical ethnobotanical content and the participation of teachers, scientists and policy makers, the participation of TEK holders from the same communities is necessary in the design and implementation of activities that promote the transmission of TEK (Reyes-García *et al.* 2010, McCarter & Gavin 2011, Sandoval-Rivera & Mendoza-Zuany 2017, Nigh & Bertely 2018); examples of those activities are ethnobotanical field trips, ethnogastronomic exhibitions, school garden projects, and storytelling, among others. Traditional knowledge plays a crucial role to outreach a healthy interaction with the environment and provides a channel for sustainable development (Mazzocchi 2006, Segger & Phillips 2015). To pursue social justice and sustainability, a collaborative intercultural dialogue and a respectful and symmetric interaction among the distinct actors of knowledge is essential (Argueta-Villamar & Pérez-Ruiz 2019).

A particularity of the education system in the study area (La Guajolota) is the presence of a high school specialized in natural resources. Thus, the promotion of citi-

zen science projects that involve the TEK from students and other community members, can be a valuable tool in the pursuit for a sustainable development in ST territory.

The results of this study suggest that among the three studied groups of young Tepehuans, non-students have a higher traditional knowledge grade about edible plants than both rural and urban students. This knowledge includes issues related to vernacular names, harvesting season, recognition of edible uses, parts of the plant that are eaten, and habitat of the plants. Results support the notion of a better TEK by people engaged in activities in the primary economic sector, and a negative association between socioeconomic factors such as formal education and TEK, probably related to the decrease in time spent living and learning in nature for attending academic activities. Furthermore, as activities related to nature lose importance, the lexicon related to biodiversity tends to decline or disappear in indigenous languages.

It was also found that women have a higher degree of traditional knowledge than men, which can be explained by the differences in gender role in this group, where women are more rooted in food preparation. This highlights the need to always involve women in environmental management processes aimed at the conservation and sustainable use of the biodiversity of the ST territory.

The socioeconomic changes that are occurring around Southern Tepehuan youth (such as migration to urban areas, less use of their indigenous language, and a formal education received almost entirely in Spanish language), is causing cultural erosion. Thus, it is important to develop strategies favoring alternative ways of transmission of the traditional knowledge, *e.g*., its inclusion into the educational curricula and the promotion of a sense of pride for the traditional cultures and languages, in order to conserve and revitalize this valuable biocultural heritage.

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Supplementary material

Supplemental data for this article can be accessed here: https://doi.org/10.17129/botsci.2792

Literature cited

Aikman S. 1999. Schooling and Development: Eroding Amazon Women's Knowledge and Diversity. *In*: Heward C., Bunwaree S., eds. *Gender, Education and Development: Beyond Access to Empowerment*. London, UK and New York, USA: Zed Books Ltd, pp. 99-153. ISBN: 1856496325

Albuquerque UP. 2006. Re-examining hypotheses concerning the use and knowledge of medicinal plants: a study in the Caatinga vegetation of NE Brazil. *Journal of Ethnobiology and Ethnomedicine* **2**: 30. DOI: https://doi.org/10.1186/1746-4269-2-30

Arango-Caro S. 2004. Ethnobotanical studies in the Central Andes (Colombia): Knowledge distribution of plant use according to informant's characteristics. *Lyonia* **7**: 89-104.

Argueta-Villamar A, Pérez-Ruiz ML. 2019. Los saberes tradicionales y los desafíos para el diálogo de conocimientos. *Desenvolvimento e Meio Ambiente* **50**: 49-72. DOI: http://dx.doi.org/10.5380/dma.v50i0.65438

Ban NC, Frid A, Reid M, Edgar B, Shaw D, Siwallace P. 2018. Incorporate indigenous perspectives for impactful research and effective management. *Nature Ecology & Evolution* **2**: 1680-1683. DOI: https://doi.org/10.1038/s41559-018-0706-0

Barreau A, Ibarra JT, Wyndham FS, Rojas A, Kozak RA. 2016. How can we teach our children if we cannot access the forest? Generational change in Mapuche knowledge of wild edible plants in Andean temperate ecosystems of Chile. *Journal of Ethnobiology* **36**: 412-433. DOI: https://doi.org/10.2993/0278-0771-36.2.412

Bensasson L. 2013. Educación intercultural en México ¿por qué y para quién?. *In*: Baronnet B, Tapia-Uribe M, coords. *Educación e interculturalidad. Política y políticas.* Cuernavaca, México: Universidad Nacional Autónoma de México and Centro Regional de Investigaciones Multidisciplinarias, pp. 49-68. ISBN: 978-607-02-4371-4

Benz B, Cevallos J, Santana F, Rosales J, Graf S. 2000. Losing knowledge about plant use in the Sierra de Manantlan Biosphere Reserve, Mexico. *Economic Botany* **54**: 183-191. DOI: https://doi.org/10.1007/BF02907821

Berkes F, Colding J, Folke C. 2000. Rediscovery of Traditional Ecological Knowledge as Adaptive Management. *Ecological Applications* **10**: 1251-1260. DOI: https://doi.org/10.2307/2641280

Berlin B. 1972. Speculations on the growth of ethnobotanical nomenclature. *Language in Society* **1**: 51-86. DOI: https://doi.org/10.1017/S0047404500006540

Boege E. 2008. *El patrimonio biocultural de los pueblos indígenas de México: hacia la conservación in situ de la biodiversidad y agrodiversidad en los territorios indígenas*. México, DF: Instituto Nacional de Antropología e Historia and Comisión Nacional para el Desarrollo de los Pueblos Indígenas. ISBN: 9680303853

Bortolotto IM, Mello-Amorozo MC, Guarim-Neto G, Oldeland J, Damasceno-Junior GA. 2015. Knowledge and use of wild edible plants in rural communities along Paraguay River, Pantanal, Brazil. *Journal of Ethnobiology and Ethnomedicine* **11**: 46. DOI: https://doi.org/10.1186/s13002-015-0026-2

Bruyere BL, Trimarco J, Lemungesi S. 2016. A comparison of traditional plant knowledge between students and herders in northern Kenya. *Journal of Ethnobiology and Ethnomedicine* **12**: 12-48. DOI: https://doi.org/10.1186/s13002-016-0121-z

Caballero J, Mapes C. 1985. Gathering and subsistence patterns among the P'urhepecha Indians of Mexico. *Journal of Ethnobiology* **5**: 31-47.

Camou-Guerrero A, Reyes-García V, Martínez-Ramos M, Casas A. 2008. Knowledge and Use Value of Plant Species in a Rarámuri Community: A Gender Perspective for Conservation. *Human Ecology* **36**: 259-272. DOI: https://doi.org/10.1007/s10745-007-9152-3

Camou-Guerrero A, Casas A, Moreno-Calles AI, Aguilera-Lara J, Garrido-Rojas D, Rangel-Landa S, Torres I, Pérez-Negrón E, Solís L, Blancas J, Guillén S, Parra F, Rivera-Lozoya E. 2016. Ethnobotany in Mexico: History, Development, and Perspectives. In: Lira R, Casas A, Blancas J, eds. *Ethnobotany of Mexico: Interactions of People and Plants in Mesoamerica*. New York, USA: Springer, 21-36 pp.

Casas A, Lira R, Torres I, Delgado A, Moreno-Calles AI, Rangel-Landa S, Blancas J, Larios C, Solís L, Pérez-Negrón E, Vallejo M, Parra F, Farfán-Heredia B, Arellanes Y, Campos N. 2016. Ethnobotany for Sustainable Ecosystem Management: A Regional Perspective in the Tehuacán Valley. *In*: Lira R, Casas A, Blancas J, eds. *Ethnobotany of Mexico: Interactions of People and Plants in Mesoamerica*. New York, USA: Springer, pp. 179-203. ISBN: 978-1-4614-6669-7

Case RJ, Pauli GF, Soejarto DD. 2005. Factors in maintaining indigenous knowledge among ethnic communities of Manus Island. *Economic Botany* **59**: 356-365.

Cavalli-Sforza LL, Feldman MW. 1981. *Cultural transmission and evolution: a quantitative approach* ***Vol. 16***. New Jersey, USA: Princeton University Press. ISBN: 9780691082837

Cramaussel C. 2013. El sistema de cargos en San Bernardino de Milpillas Chico, Durango. *Culturales* **1**: 69-104.

Dan Guimbo I, Muller J, Larwanou M. 2011. Ethnobotanical knowledge of men, women and children in rural Niger: a mixed-methods approach. *Ethnobotany Research and Applications* **9**: 235-242.

Eyssartier C, Ladio AH, Lozada M. 2008. Cultural transmission of traditional knowledge in two populations of north-western Patagonia. *Journal of Ethnobiology and Ethnomedicine* **4**: 25. DOI: https://doi.org/10.1186/1746-4269-4-25

García-Hilario F, Cruz-Morales J, Castro-Ramírez AE, Trench-Hamilton T, Pacheco-Flores C. 2016. Crisis del sistema milpero: la erosión biológica y cultural en San Juan de las Nieves, Malinaltepec, Guerrero, México. *Revista de Geografía Agrícola*: **57**: 113-123.

González-Elizondo M. 1991. Ethnobotany of the Southern Tepehuan of Durango, Mexico: I. Edible Mushrooms. *Journal of Ethnobiology* **11**: 165-173.

González-Elizondo M, Galván R. 1992. El maguey (*Agave* spp.) y los Tepehuanes de Durango. *Cactáceas y Suculentas Mexicanas*: **37**: 3-11.

González-Elizondo M, González-Elizondo MS. 1994. Flora Medicinal Tepehuana del Sur de Durango. *In*: Aguilar A, Argueta A, Cano L, coords. *Flora Medicinal Indígena de México* ***vol. 1***. México: Instituto Nacional Indigenista, pp. 455-530. ISBN: 9682970148

González-Elizondo M, González-Elizondo MS, López-Enríquez L, Tena-Flores JA. 2001. Herbolaria Tepehuana. Interciencia (CIIDIR) **1**: 1-13.

González-Elizondo M, López-Enríquez L, González-Elizondo MS, Tena-Flores JA. 2004. Plantas medicinales del estado de Durango y zonas aledañas. México, DF: Instituto Politécnico Nacional. ISBN: 9703600662

González-Elizondo M, González-Elizondo MS, López-Enríquez IL, Herrera-Arrieta Y. 2017. Importancia económica y usos tradicionales de la flora. *In*: Cruz-Angón A, Castaños-Rochell E, Valero-Padilla J, Melgarejo E, coords. *La biodiversidad en Durango. Estudio de Estado.* México: Comisión Nacional para el Conocimiento y Uso de la Biodiversidad and Secretaría

de Recursos Naturales y Medio Ambiente, pp. 513-528. ISBN: 978-607-8328-97-0

González-Elizondo MS. 1997. Upper Mezquital River region, Sierra Madre Occidental, Mexico. *In*: Davis SD, Heywood VH, Herrera-MacBryde O, Villa-Lobos J, Hamilton AC, eds. *Centres for plant diversity: a guide and strategy for their conservation*, Vol. 3. Cambridge, UK: The World Wide Fund for Nature (WWF) and IUCN-The World Conservation Union, pp. 157-160. ISBN: 2-8317-0199-6

González-Elizondo MS, González-Elizondo M, Tena-Flores JA, Ruacho-González L, López-Enriquez IL. 2012. Vegetación de la Sierra Madre Occidental, México: una síntesis. *Acta Botánica Mexicana* **100**: 351-403. DOI: https://doi.org/10.21829/abm100.2012.40

Haselmair R, Pirker H, Kuhn E, Vogl CR. 2014. Personal networks: a tool for gaining insight into the transmission of knowledge about food and medicinal plants among Tyrolean (Austrian) migrants in Australia, Brazil and Peru. *Journal of Ethnobiology and Ethnomedicine* **10**: 1. DOI: https://doi.org/10.1186/1746-4269-10-1

Hewlett BS, Cavalli-Sforza LL. 1986. Cultural Transmission Among Aka Pygmies. *American Anthropologist* **88**: 922-934. DOI: https://doi.org/10.1525/aa.1986.88.4.02a00100

Hickling-Hudson A, Ahlquist R. 2003. Contesting the curriculum in the schooling of Indigenous children in Australia and the United States: From Eurocentrism to culturally powerful pedagogies. *Comparative Education Review* **47**: 64-89. DOI: https://doi.org/10.1086/345837

Kujawska M, Łuczaj Ł. 2015. Wild Edible Plants Used by the Polish Community in Misiones, Argentina. *Human Ecology* **43**: 855-869. DOI: https://doi.org/10.1007/s10745-015-9790-9

Laferrière JE. 1992. Cultural and environmental response to drought among the mountain Pima. *Ecology of Food and Nutrition* **28**: 1-9. DOI: https://doi.org/10.1080/03670244.1992.9991256

Mapes C, Basurto F. 2016. Biodiversity and Edible Plants of Mexico. *In*: Lira R, Casas A, Blancas J, eds. *Ethnobotany of Mexico: Interactions of People and Plants in Mesoamerica*. New York, USA: Springer, pp. 83-126. ISBN: 978-1-4614-6669-7

Martínez-López J, Martínez-y Ojeda E, Blancas J, Maldonado-Cruz P. 2016. Variables sociodemográficas y su relación con el número de recursos forestales no maderables en dos comunidades zapotecas de la Sierra Juárez de Oaxaca. *Temas de Ciencia y Tecnología* **20**: 29-36.

Maseko H, Shackleton CM, Nagoli J, Pullanikkatil D. 2017. Children and Wild Foods in the Context of Deforestation in Rural Malawi. *Human Ecology* **45**: 795-807. DOI: https://doi.org/10.1007/s10745-017-9956-8

Mazzocchi F. 2006. Western science and traditional knowledge. Despite their variations, different forms of knowledge can learn from each other. *EMBO reports* **7**: 463-466. DOI: https://doi.org/10.1038/sj.embor.7400693

McCarter J, Gavin MC. 2011. Perceptions of the value of traditional ecological knowledge to formal school curricula: opportunities and challenges from Malekula Island, Vanuatu. *Journal of Ethnobiology and Ethnomedicine* **7**: 38. DOI: https://doi.org/10.1186/1746-4269-7-38

McMillen H. 2012. Ethnobotanical Knowledge Transmission and Evolution: The Case of Medicinal Markets in Tanga, Tanzania. *Economic Botany* **66**: 121-131. DOI: https://doi.org/10.1007/s12231-012-9201-8

Monroy R, Ayala I. 2003. Importancia del conocimiento etnobotánico frente al proceso de urbanización. *Etnobiología* **3**: 79-92.

Mosquera-Mena RA, Santamaría-Poli T, López-Almansa JC. 2015. Sistemas de transmisión del conocimiento etnobotánico de plantas silvestres comestibles en Turbo, Antioquia, Colombia. *Revista de Investigación Agraria y Ambiental* **6**: 133-1143.

Muñoz LA, Cobos A, Diaz O, Aguilera JM. 2013. Chia seed (*Salvia hispanica*): an ancient grain and a new functional food. *Food Reviews International* **29**: 394-408. DOI: https://doi.org/10.1080/87559129.2013.818014

Narváez-Elizondo RE, González-Elizondo M, González-Elizondo MS, Tena-Flores JA, Castro-Castro A. 2020. Edible ethnoflora of the Southern Tepehuans of Durango, Mexico. *Polibotánica* **50**: 245-277. DOI: https://doi.org/10.18387/polibotanica.50.15

Navarrete-Linares F. 2008. Los pueblos indígenas de México. México, D.F.: Comisión Nacional para el Desarrollo de los Pueblos Indígenas. ISBN: 978-970-753-157-4

Nguyen MLT. 2003. Comparison of Food Plant Knowledge Between Urban Vietnamese Living in Vietnam and in Hawai'i. *Economic Botany* **57**: 472-480.

Nigh R, Bertely M. 2018. Conocimiento y educación indígena en Chiapas, México: un método intercultural. *Diálogos sobre Educación* **9**: 1-20. DOI: https://doi.org/10.32870/dse.v0i16.395

Ochoa JJ, Ladio AH. 2015. Plantas silvestres con órganos

subterráneos comestibles: transmisión cultural sobre recursos subutilizados en la Patagonia (Argentina). *Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas* **14**: 287-300.

Pardo-de Santayana M, Tardío J, Morales R. 2005. The gathering and consumption of wild edible plants in the Campoo (Cantabria, Spain). *International Journal of Food Sciences and Nutrition* **56**: 529-542. DOI: https://doi.org/10.1080/09637480500490731

Peredo S, Barrera C. 2017. Usos etnobotánicos, estrategias de acción y transmisión cultural de los recursos vegetales en la región del Maule, zona centro sur de Chile. *Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas* **16**: 398-409.

Pío-León JF, Delgado-Vargas F, León-de la Luz JL, Ortega-Rubio A. 2017. Prioritizing wild edible plants for potential new crops based on deciduous forest traditional knowledge by a rancher community. *Botanical Sciences* **95**: 47-59. DOI: https://doi.org/10.17129/botsci.772

Quinlan MB, Quinlan RJ. 2007. Modernization and medicinal plant knowledge in a Caribbean horticultural village. *Medical Anthropology Quarterly* **21**: 169-192. DOI: https://doi.org/10.1525/maq.2007.21.2.169

Ramirez CR. 2007. Ethnobotany and the loss of traditional knowledge in the 21st century. *Ethnobotany Research and Applications* **5**: 245-247.

Ramos-Hernández M, Ávila-Bello CH, Morales-Mávil JE. 2007. Etnobotánica y ecología de plantas utilizadas por tres curanderos contra la mordedura de serpiente en la región de Acayucan, Veracruz, México. *Boletín de la Sociedad Botánica de México* **81**: 89-100. DOI: https://doi.org/10.17129/botsci.1768

Redžić S. 2010. Use of wild and semi-wild edible plants in nutrition and survival of people in 1430 days of siege of Sarajevo during the war in Bosnia and Herzegovina (1992-1995). *Collegium Antropologicum* **34**: 551-570.

Reyes-García V, Vadez V, Huanca T, Leonard WR, McDade T. 2007. Economic Development and Local Ecological Knowledge: A Deadlock? Quantitative Research from a Native Amazonian Society. *Human Ecology* **35**: 371-377. DOI: https://doi.org/10.1007/s10745-006-9069-2

Reyes-García V, Kightley E, Ruiz-Mallén I, Fuentes-Peláez N, Demps K, Huanca T, Martínez-Rodríguez MR. 2010. Schooling and local environmental knowledge: Do they complement or substitute each other?. *International Journal of Educational Development* **30**: 305-313. DOI: https://doi.org/10.1016/j.ijedudev.2009.11.007

Reyes-Valdez JA. 2007. Los alimentos de los dioses. La tradición culinaria de los tepehuanes del sur de Durango. *Transición*: **35**: 59-79.

Sánchez-Álvarez M. 2012. Patrimonio biocultural de los pueblos originarios de Chiapas: retos y perspectivas. *In*: Ávila-Romero A, Vázquez LD, coords. *Patrimonio biocultural, saberes y derechos de los pueblos originarios*. San Cristóbal de Las Casas, Chiapas, México: Universidad Intercultural de Chiapas, pp. 83-98. ISBN: 978-607-9147-43-3

Sánchez-Olmedo JG. 1980. *Etnografía de la Sierra Madre Occidental: tepehuanes y mexicaneros*. México: Secretaría de Educación Pública and Instituto Nacional de Antropología e Historia.**92.**

Sandoval-Rivera JCA, Mendoza-Zuany RG. 2017. Intercultural educational alternatives based on sustainability from Mexico: beyond school and cultural belonging. *Intercultural Education* **28**: 373-389. DOI: https://doi.org/10.1080/14675986.2017.1334313

Saynes-Vásquez A, Caballero J, Meave JA, Chiang F. 2013. Cultural change and loss of ethnoecological knowledge among the Isthmus Zapotecs of Mexico. *Journal of Ethnobiology and Ethnomedicine* **9**: 40. DOI: https://doi.org/10.1186/1746-4269-9-40

Segger MCC, Phillips FK. 2015. Indigenous traditional knowledge for sustainable development: the biodiversity convention and plant treaty regimes. *Journal of Forest Research* **20**: 430-437. DOI: https://doi.org/10.1007/s10310-015-0498-x

Srithi K, Balslev H, Wangpakapattanawong P, Srisanga P, Trisonthi C. 2009. Medicinal plant knowledge and its erosion among the Mien (Yao) in northern Thailand. *Journal of Ethnopharmacology* **123**: 335-342. DOI: https://doi.org/10.1016/j.jep.2009.02.035

Sõukand R. 2016. Perceived reasons for changes in the use of wild food plants in Saaremaa, Estonia. *Appetite* **107**: 231-241. DOI: https://doi.org/10.1016/j.appet.2016.08.011

Sternberg RJ, Nokes C, Geissler PW, Prince R, Okatcha F, Bundy DA, Grigorenko EL. 2001. The relationship between academic and practical intelligence: A case study in Kenya. *Intelligence* **29**: 401-418. DOI: https://doi.org/10.1016/S0160-2896(01)00065-4

Tardío J, Pardo-de Santayana M, Morales R. 2006. Ethnobotanical review of wild edible plants in Spain. *Botanical Journal of the Linnean Society* **152**: 27-71. DOI: https://doi.org/10.1111/j.1095-8339.2006.00549.x

Tbatou M, Fagroud M, Belahyan B, Belahsen R. 2016. Wild edible plants traditionally used in the countryside

of El Jadida, coastal area in the Center of Morocco: Assessing traditional knowledge erosion. *Life Sciences Leaflets* **78**: 30-51.

Thakur D, Sharma A, Uniyal SK. 2017. Why they eat, what they eat: patterns of wild edible plants consumption in a tribal area of Western Himalaya. *Journal of Ethnobiology and Ethnomedicine* **13**: 70. DOI: https://doi.org/10.1186/s13002-017-0198-z

Theien I. 2009. Food rationing during World War two: a special case of sustainable consumption? *Anthropology of Food*. S5. DOI: https://doi.org/10.4000/aof.6383

Toledo VM, Barrera-Bassols N. 2008. *La memoria biocultural: la importancia ecológica de las sabidurías tradicionales* ***Vol. 3***. Barcelona, Spain: Icaria Editorial. ISBN: 978-84-9888-001-4

Torres-Sánchez N. 2018. *Aquí hablamos tepehuano y allá español*. *Un estudio de la situación de bilingüismo incipiente entre español y tepehuano del sureste (o'dam) en Santa María de Ocotán y Durango*. PhD Thesis. El Colegio de México.

Ulloa-Ulloa C, Acevedo-Rodríguez P, Beck S, Belgrano MJ, Bernal R, Berry PE, Brako L, Celis M, Davidse G, Forzza RC, Gradstein SR, Hokche O, León B, León-Yánez S, Magill RE, Neill DA, Nee M, Raven PH, Stim PM. 2017. An integrated assessment of the vascular plant species of the Americas. *Science* **358**: 1614-1617. DOI: https://doi.org/10.1126/science.aao0398

United Nations. 1992. *Convention on Biological Diversity*. Rio de Janeiro, Brazil: United Nations. https://www.cbd.int/doc/legal/cbd-en.pdf (accessed July 5, 2018).

United Nations. 2007. *United Nations Declaration on the Rights of Indigenous Peoples*. New York, USA: United Nations General Assembly. https://www.un.org/development/desa/indigenouspeoples/wp-content/uploads/sites/19/2018/11/UNDRIP_E_web.pdf (accessed May 24, 2019).

Villaseñor JL. 2016. Checklist of the native vascular plants of Mexico. *Revista Mexicana de Biodiversidad* **87**: 559-902. DOI: http://dx.doi.org/10.1016/j.rmb.2016.06.017

Voeks RA, Leony A. 2004. Forgetting the forest: Assessing medicinal plant erosion in Eastern Brazil. *Economic Botany* **58**: 294-306.

Vorstenbosch T, de Zwarte I, Duistermaat L, van Andel T. 2017. Famine food of vegetal origin consumed in the Netherlands during World War II. *Journal of Ethnobiology and Ethnomedicine* **13**: 63. DOI: https://doi.org/10.1186/s13002-017-0190-7

Wester L, Yongvanit S. 1995. Biological diversity and community lore in northeastern Thailand. *Journal of Ethnobiology* **15**: 71-88.

Wyndham FS. 2010. Environments of Learning: Rarámuri Children 's Plant Knowledge and Experience of Schooling, Family, and Landscapes in the Sierra Tarahumara, Mexico. *Human Ecology* **38**: 87-99. DOI: https://doi.org/10.1007/s10745-009-9287-5

Xingú-López A, González-Huerta A, de la Cruz-Torres E, Sangerman-Jarquín D, Orozco-de Rosas G, Rubí-Arriaga M. 2017. Chía (*Salvia hispanica* L.), situación actual y tendencias futuras. *Revista Mexicana de Ciencias Agrícolas* **8**: 1619-1631. DOI: https://doi.org/10.29312/remexca.v8i7.516

Yates S, Ramírez-Sosa CR. 2004. Ethnobotanical knowledge of *Brosimum alicastrum* (Moraceae) among urban and rural El Salvadorian adolescents. *Economic Botany* **58**: 72-77.

Zent S. 2001. Acculturation and Ethnobotanical Knowledge Loss among the Piaroa of Venezuela: Demonstration of a Quantitative Method for the Empirical Study of Traditional Environmental Knowledge Change. *In*: Maffi L, ed. *On Biocultural Diversity: Linking Language, Knowledge, and the Environment*. Washington, USA: Smithsonian Institution Press, pp. 190-211. ISBN: 978-1560989301

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