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Variation of Ethnomycological Knowledge in a Community from Central Mexico

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Abstract

We analyze the effects of the ethnomycological knowledge depending on the age range of its users and how far their homes are from the forest areas. As a study model, the traditional mycological knowledge of San Pedro Tlalcuapan SPT, in Central Mexico was used. During 2017, 135 semi-structured interviews were conducted with people of three age ranges and living in three areas of the community located at different distances from the forest. Data was analyzed using descriptive statistics and analyses of non-metric multidimensional scaling, which were then applied to calculate two indices. The effect of age and origin of the individuals on bio-cultural relevance was assessed using multiple linear regression models. Fifty species of edible wild mushrooms were registered, those mentioned most often were of the *Russula delica* complex., *Amanita basii* and *Boletus* aff. *edulis*. Ninety-five percent of the people interviewed consumed wild mushrooms on average two times a week, while 57% collected them. Wild mushrooms are mainly recognized for their food and ecological importance. Ordination and regression analyses show that people closest to the forest, as well as older people, are able to identify more of the wild mushrooms and have greater bio-cultural mushroom awareness. Results show that there is a risk that traditional knowledge about wild mushrooms will disappear, since it is only popular in a part of the community and only at some age ranges, indicating that there is a disconnect in the transfer of knowledge.

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Introduction

Bio-cultural heritage is maintained by traditional knowledge, which is a belief system (cosmos), knowledge (corpus) and practice (praxis) that have been generated, specialized, shared and transferred across generations in native communities, according to the characteristics and the needs of each people. This knowledge is transferred through conversation. This transference is weakened and may possibly become extinct if communities no longer reassess it, use it and pass it on [1, 2].

Different socieconomic pressures have resulted in a series of modifications in the use of natural resources, which has threatened and endangered bio-cultural diversity [3, 4, 5]. It has been observed a cultural change driven by the formal education systems [6, 7, 8], the integration of local communities in the market economies [9]; the restriction on access to resources through conservation programs [10], in addition to the processes of modernization that include, introduction of technology, urbanization and modern health services [11].

This cultural change has been reflected in the variation of the distribution of traditional knowledge. The age, gender and profession are some factors that influence the diversity and richness of this knowledge ([12]. It has been documented that older persons embrace greater local knowledge [13]. As well, persons involved in few or no environment-related activities have less traditional knowledge [12, 14, 15]). In other words, elderly people and/or those connected with the environment are currently protecting this traditional environmental knowledge and can pass on to other generations.

Wild mushrooms play an important ecological [16] and cultural role in many communities, from pre-Hispanic times. Even, today, they continue to be a valuable forest resource that provide much-needed income for many families in the world [17]. Various studies have described differences in the ethnomycology knowledge within communities or by gender [18, 19, 20, 21]), and by age [22, 23]. So far, however, we did not have the tools to discover the causes and ways in which traditional mycological knowledge about mushrooms is distributed.

San Pedro Tlalcuapan (SPT) is a community of indigenous nahua ancestry, located in the slopes of the National Park La Malinche (PNLM) in Tlaxcala, Mexico. Activities, such as collecting mushroom and edible or medicinal plants contributed to the generation of knowledge, ideas and myths, as well as to the local economy. Currently, natural resources are dwindling, resulting in a change and detachment from traditional ecological knowledge. Concerned about this situation, local authorities and members of the community have shown interest in reaffirming and supporting the conservation of their bio-cultural heritage.

This paper, therefore, explores the effect that the distance from a house to the forest has on the preservation of traditional knowledge as well as the change of knowledge according to age. Then can we develop a strategy for the conservation of the area's mycological resources and the knowledge about them.

Materials and Methods

Study Area

The community of SPT, located in the Northwest part of the PNLM (19 ° 16' 50.02 'N, 98 ° 09' 0630' W), is a municipality of Santa Ana Chiautempan, in the State of Tlaxcala, Mexico (Fig. 1). It has an altitude of 2,411 meters above sea level, in an area characterized by precipitation averaging 901 mm a year and annual temperatures averaging 15.75 ° C. The community is surrounded by pine forests, pine-oak forests, oak-pine forests, each with different levels of conservation, as well as man-introduced grassland and temporary agriculture [24].

San Pedro Tlalcuapan extends along 1,162 hectares, of which approximately 600 are covered by crops and forest; the rest belongs to the local population, which is divided into three main areas: La Defensa, La Iglesia and La Colonia (Fig. 1). La Defensa is the area closest to the forest, located 200 m from it. La Iglesia is located in the center of the village, about 2.5 km away from the forest, and La Colonia, situated on the outskirts of the village, is the farthest from the forest (4.4 km) and closer to the city of Santa Ana Chiautempan (2.2 km).

Tlalcuapan has 3,613 people spread over 837

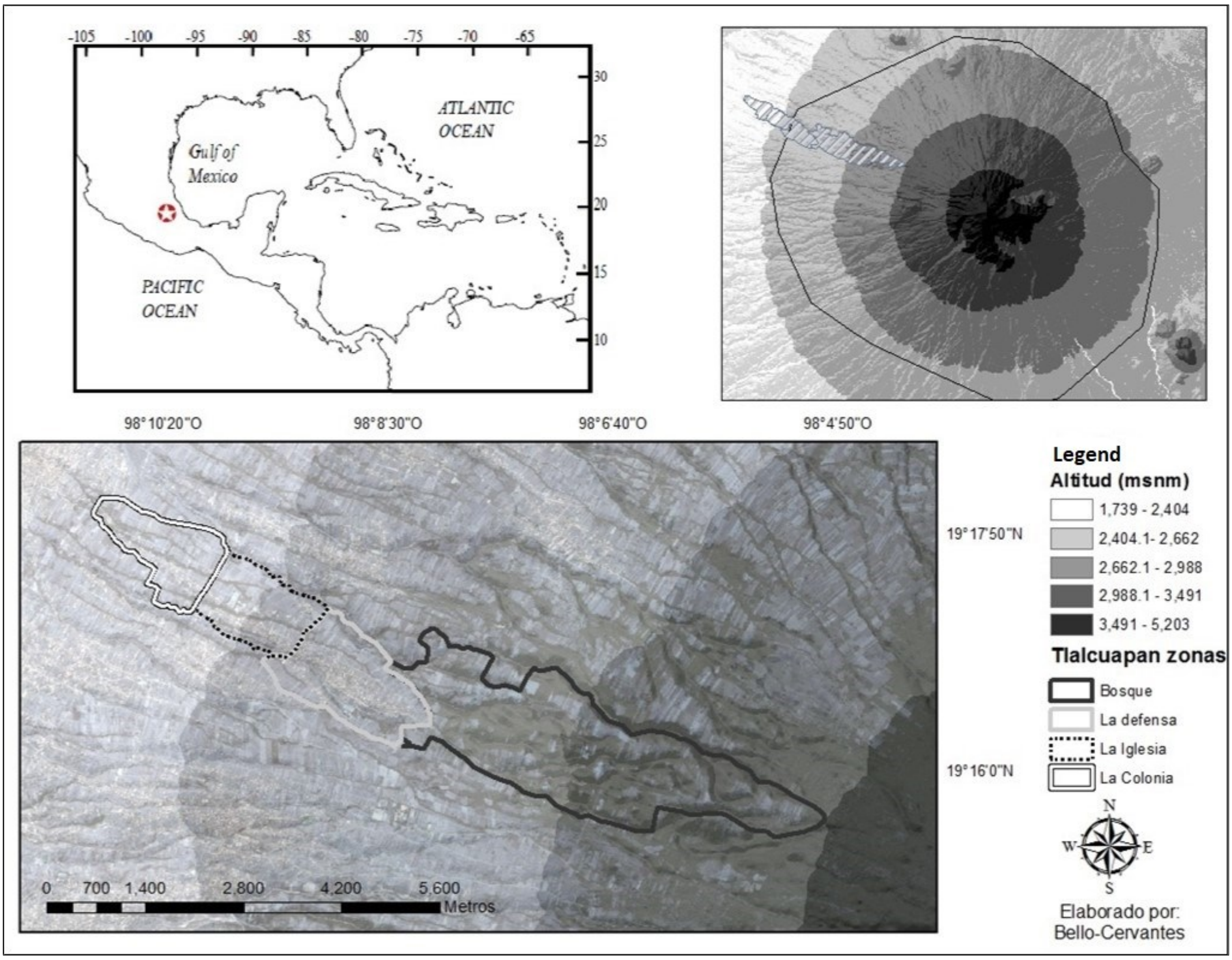

Figure 1. Location of the SPT in the National Park La Malinche Tlaxcala, Mexico. Top left of the image represents the location of the National Park La Malinche inside Mexico. Top right, represents SPT within the national park. In the lower part of the image, the 4 main areas of the studio area are shown.

households, 45% of the population is between 20 and 59 years of age, 10% is older than 60, and 13% of the population still speaks the Nahua (native language) [24].

Fieldwork and Interviews

Before this research started, we requested permission from the local authorities of the community to conduct it, notifying them about the project and requesting the consent of each interviewee.

Field trips were undertaken in the 2017 rainy season, accompanied by local people who knew the local mushrooms (hongueros), to learn the uses and names of the mushrooms, their seasons and where they grew. The mushrooms collected were identified taxonomically and deposited in the TLXM herbarium.

A semi-structured interview [25] was designed that included three aspects: (a) the respondent's personal information, including name, gender, origin, age and occupation; (b) edible mushroom-free listing, where each person was asked to name 20 mushroom he or she knew; (c) questions about each mushroom's bio-cultural importance (use, who uses it, how many times per week it is used, since when it has been used, way to get the mushrooms, harvesting activity, current or obsolete activity, its role in the forest and local management of mushroom collection and declared significance.

The interviews were divided into three groups of 45 individuals each. Each group corresponded to the areas in which the community is divided. The groups were composed of people of different ages, ranging from 8 to 90 years, which were classified into three age ranges: youth (8-20 years old), adults (21-60 years old) and older adults (persons over 60 years); each age range consisted of 15 individuals. In total, 135 people were interviewed, representing 15% of the main households of Tlalcuapan.

Statistical Analysis

The data obtained was analyzed with descriptive statistics to determine the importance that mushrooms have in the community. Two analyses of Multidimensional Non-Metric Scaling (NMDS) were applied to calculate two indices: a) Ethnotaxa Index (EI), to group persons according to the mushrooms mentioned in the free listing task, B) Bio-Cultural Significance Index (BCSI), to evaluate the Cultural significance of mushrooms, between the interviewed persons.

A qualitative matrix (46 X 135 OTUs or persons) was constructed with mushroom local names, age and home location of each person (from the three studied areas) to calculate de EI. In the case of BCSI, another qualitative matrix (29 X 135 OTUs or persons) was constructed, using the third section of the interview data, age and home location of each person (from the three studied areas). Responses to each question were coded as binary variables [26]. A similitude analysis was carried out using the Euclidian distance index, followed by a NMDS Ordination analysis. So that each individual's scores represent each index. All eigenvalues, their percentages and their cumulative percentages were obtained. The age and origin of the interviewed persons were used to explain the scores obtained by them in each index (EI, BCSI). This relationship was assessed using models of multiple linear regression [27], with the score of each person in the index as the dependent variable, and the age and origin as explanatory variables. Finally, a third linear regression was developed to evaluate the relationship between EI and BCSI. All analyses were carried out in the program R [28].

Results

Relevance of Edible Wild Mushrooms in SPT

The people of Tlalcuapan use 70 traditional names for the edible wild mushrooms found in the area, of which 39 are in Spanish and 31 in Nahua. These names correspond to 46 ethnotaxa and 50 species (Table 1). Most of the people interviewed (80%) identified more than two edible mushrooms. The mushrooms most often mentioned were *Russula delica* complex, *Amanita basii* and *Boletus* aff. *edulis*.

The data shows that people living in the area of La Defensa (the closest to the forest) were able to name more mushrooms, compared to the people in the other areas. The results also show that, regardless of the place of origin, older people can identify more types of mushrooms than the younger ones can (Fig. 2).

The young people named, in total, 30 mushrooms. The young person who recognized more species, mentioned a maximum of 21. In this age group, 71% identified 6 mushroom or fewer. Among the adults, in total, 39 different mushrooms were identified, 56% identifying 8 or fewer mushrooms. It is notable, however, that at least 20% of the adults identified 31 or more mushrooms. Older adults named a total of 40 mushrooms, and 76% knew 16 mushrooms or more (Fig. 3).

People in the community identify six areas and/or types of vegetation where the different edible mushrooms are collected: (1) pine (*Pinus)* forest, (2) oak (*Quercus)* forest, (3) oyamel (*Abies)* forest), (4) Zacatón (grassland of *Stipa ichu*), (5) agricultural land and (6) burn sites. The *Pinus* forest has the greatest abundance of mushrooms (30 spp.), followed by the *Quercus* forest (15 spp.) and the agricultural land (Table 1).

The interviews show that people get the most mushrooms by direct harvesting. Only 38% of the population purchases them and 5% does not eat them. People who harvest mushroom live mostly in La Defensa and in the La Iglesia region (Table 2).

During mushroom season, eating mushrooms is very common in these communities, with locals eating them about twice a week, although it does vary depending on the area where people live. In La Defensa, young people and adults consume mushrooms, on average, two times a week, but older adults eat them three times a week. In La Iglesia, all three age ranges ate mushrooms at least once a week and, in the case of the area farthest from the forest (La Colonia), young people no longer eat them, whereas adults and older people eat mushrooms on average once a week

Table 1. Wild mushroom name, tradicional name and place of growth known in SPT. Organization based to the frecuency mentioned.

Scientific Name	Common Spanish name	Common Nahualt name	Mention frequency	Vegetation and ground use					
				P	Q	G	A	B	C
Russula brevipes Peck *Russula* complex. *Delica* Fr.	Tecajete	Tecax Tecax	102 102	X X		X			
Amanita basii Guzmán & Ram.-Guill	Amarillo, Flor (Yellow, flower)	Ayoxochitl	97	X					
Boletus complex. *Edulis* Bull.		Pante	92	X		X			
Ramaria spp.	Escobeta (Broom)	Xelwas	73	X					
Hebeloma aff. *mesophaeum* (Pers.) Quél.	Xolete de chambus-quina (Xolete from burned areas)	Xoletl	70					X	
Cantharellus aff. *cibarius* Fr.		Tecosa	65		X	X			
Laccaria trichodermophora G.M. Muell.		Xoxoco-yuli	64	X					
Suillus pseudobrevipes A.H. Sm. & Thiers	Pancita (Little belly)	Poposo	61	X	X				
Turbinellus floccosus (Schwein.) Singer	Corneta (Trumpet)	Tlapitzal	52				X		
Agaricus campestris L.	Llanero, Hongo de pasto (Plain or grass mushroom)	Ayutzi	48						X
Lyophyllum aff. *decastes* (Fr.) Singer.		Tzenzo	48		X				
Lactarius indigo (Schwein.) Fr.	Tecax azul (Blue tray)	Tlapalte-cax	47	X	X				
Pleorotus opuntiae (Durieu & Léville) Sacc.	Hongo de maguey (Maguey mush-room)	Meso-nanatl	38						X
Chroogomphus jamaicensis (Murrill) O.K. Mill.	Borracho (Drunk)	Tlapalte-cosa	24	X	X				
Hygrophorus chrysodon (Batsch) Fr.	Señorita, Palomita (Miss, Little dove)	Totolte-nanacatl	24	X					
Lycoperdon perlatum Pers.	Huevito blanco, Tzefamil chico (White little egg, Little tzefamil)	Popote	24	X		X			
Calvatia cyathiformis Fr.		Tzefamil	22						X

Rhizopogon aff. *michoacanicus* Trappe & Guzmán	Huevito (Little egg)	Xitetl	21	X				X	
Amanita sp.		Cuehcuex	20						X
Hypomyces lactifluorum (Schwein.) Tul. & C. Tul.	Chilnanzi naranja (Orange chilnantzi)	Chilnanzi, Chilnanacatl	20	X					
Hypomyces macrosporus Seaver	Chilnanzi café (Brown chilnanzi)	Chilnanzi, Chilnanacatl	19	X					
Reticularia lycoperdon Bull. (Myxomycete)	Caca de luna (Moon shit)	Cuahtechol	13	X					
Lactarius deliciosus (L.) Gray	Enchiladito (With chile)	Tlapaltecax, Ocotecax	12	X					
Amanita amerifulva Tulloss	Venadito, casco de soldado (Little deer, soldier's helmet)		11	X					
Auricularia auricula-judae Bull.	Oreja ratón de tronco (Mouse ear's trunk)	Quimixnacas	8				X		
Lyophyllum sp.		Oco-Tzenzo	7	X					
Morchella snyderi M. Kuo & Methven	Chipotle		7				X		
Agaricus bisporus J.E. Lange	Champiñon		6						
Ustilago maydis (DC.) Corda		Cuitlacoche	5						X
Infundibulicybe gibba Pers.	Cueros, sombrillitas (Leather, Little umbrella)	Nacas cuero	4	X	X		X		
Macrolepiota aff. *procera* (Scop.) Singer		Tulnanacatl	4	X					X
Amanita complex. *rubescens* Pers	Mantequilla (Butter)		3	X					
Armillaria complex. *mellea*		Xopitzal	3		X				
Infundibulicybe sp.		Totomox-	3		X				
Ramaria aff. *suecica* (Fr.) Donk	Escobeta café, Escobilla de ocote (Brown broom)	Xelhuas	3	X					
Ramaria cf. *cystidiophora*	Escobeta café	Xelhuas	3		X				
Tricholoma flavovirens (Pers.) S. Lundell	Railita, Kailita		3	X					
Amanita elongata Peck	Yema		2	X		X			
Gymnopus complex. *dryophillus* (Bull.) Murrill	Xolete pata amarilla (Yellow foot xolete)	Xoletl	2	X					

Helvella crispa Bull.	Oreja de ratón, Soldadito (Mouse ear's, soldier)	Xocuepich	2	X	X				
Laccaria sp.		Xoxocoyuli cihuatl	2	X	X				
Lactarius salmonicolor R. Heim & Leclair	Enchilado de oyamel (Mushroom with chile from fir)	Ayometecax	2				X		
Ramaria aff. *rasilispora* Marr & D.E. Stuntz	Escobeta amarilla (Yellow broom)	Xelhuas	2		X				
Ramaria rubricarnata Marr & D.E. Stuntz	Escobeta amarilla (Yellow broom)	Xelhuas	2		X				
Ramaria rubripermanens Marr & D.E. Stuntz	Escobeta rosa (Pink broom)	Xelhuas	2		X				
Russula complex. *xerampelina* (Schaeff.) Fr.	Pastelito (Little cake)		2	X					
Agaricus sp.	Llanero de monte (Mountain Llanero)		1	X					
Clavariadelphus truncatus	Acocote		1		X				
Pholiota lenta (Pers.) Singer	Xolete de ocote (Pine's xolete)	Ocoxoletl	1	X					
Total mushroom by vegetation and ground use				30	15	5	5	2	6

* P = pine forest, O = oak forest, G = grassland, A = fir forest, B = burned areas, C = cropland.

Table 2. Perspective about mushroom harvesting and consumption, by different age groups in the three main areas of San Pedro Tlalcuapan.

Area	Age Group	Buy*	Harvest	Weekly consume	Participate during harvesting	Age of activity	
						Past	Past/present
La Defensa	Youth	2	14	2	13	2	13
	Adults	4	14	2	14	1	14
	Old adults	4	15	3	15	0	15
La Iglesia	Youth	5	11	1	8	5	10
	Adults	12	12	1	13	2	13
	Old adults	11	12	1	14	2	13
La Colonia	Youth	8	8	0	7	5	10
	Adults	11	6	1	12	5	10
	Old adults	11	9	1	15	4	11

*Buy: this column indicates the number of people interviewed who buy the mushrooms. Harvest: Indicates how many people collect them. Weekly consume: Is the average of how many times per week eat mushrooms. Participate during harvesting: Indicates the number of interviewees who participate in the harvest. Age of activity: Number of interviewees who consider the collection and consumption of fungi as obsolete or as something in force.

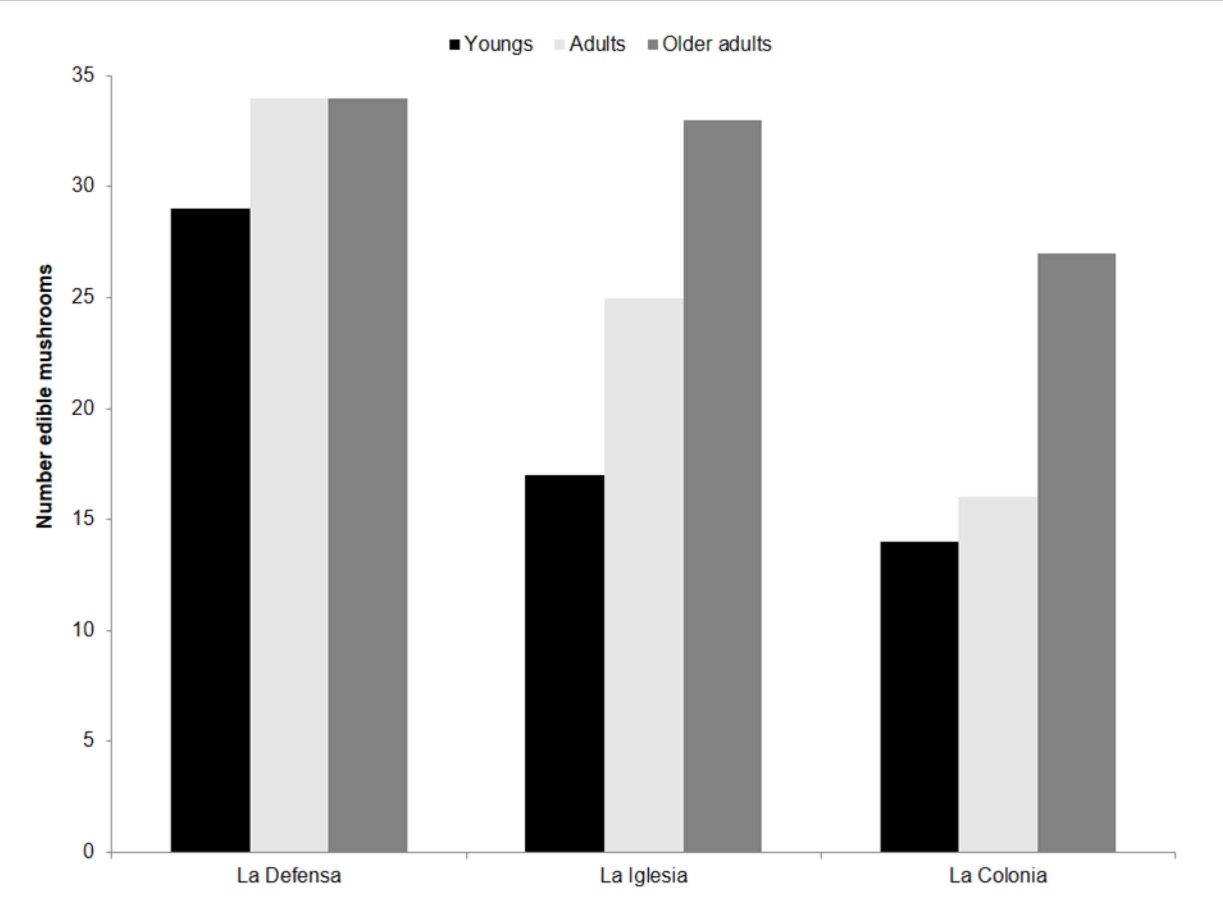

Figure 2. Number of edible mushrooms mentioned by each age range in the three areas of the community.

(Table 2).

During fieldwork in the forest, it was noted that collection is a family activity, involving at least two generations, which includes children, young people, adults and the elderly, and the transmission of knowledge about mushrooms is mostly consecutive. In other words it is passed along from the grandparents to their children and grandchildren, and so on, from generation to generation.

Table 2 shows that the people of La Defensa participate in mushrooms gathering regardless of age (young people, adults and the elderly), but the participation of children decreases at more distant forest sites. Most people (75% of respondents) consider collecting mushrooms as being a part of current ancestral knowledge and when you get farther away from the forest (La Iglesia and La Colonia), it is considered to be antiquity (Table 2).

During fieldwork in the forest and in the interviews, the fruiting season of each ethnotaxa was recorded. The mushroom season comprises six months, running from May to October, with July and August being the time of the greatest abundance of ethnotaxa (Table 3).

As for the role that mushrooms play in the forest, the people interviewed considered their greatest contribution to be a fertilizer for trees, as well as producing seeds to make more mushrooms in the following seasons. They are also food for forest animals and, to a lesser extent, act as disintegrator. Ninety-one percent of those interviewed recognize that there is a close relationship between mushrooms and trees.

Furthermore, three major "controlling" strategies were mentioned as ways to preserve mushrooms. The first is that, when harvesting, one should leave a part of the mushroom in the place where it is found; another is

Table 3. Wild mushrooms growing during the season (May-October 2017), in SPT, Tlaxcala.

Mushroom species	May	June	Juy	August	September	October
Agaraicus campestris	X					
Reticularia lycoperdon	X					
Pleurotus opuntiae	X	X				
Calvatia cyathiformis	X	X				
Rhizopogon complex aff. *michoacanicus*	X	X				
Hebeloma aff. mesophaeum	X	X				
Agaricus bisporus	X	X	X	X	X	X
Lyophyllum aff. decastes		X	X			
Amanita sp.		X	X			
Lyophyllum sp.		X	X			
Macrolepiota aff. procera		X	X			
Lactarius aff. salmonicolor		X	X	X		
Amanita basii		X	X	X		
Pholiota lenta		X	X	X		
Boletus aff. edulis		X	X	X	X	
Suillus pseudobrevipes		X	X	X	X	
Lactarius indigo		X	X	X	X	
Lactarius deliciosus		X	X	X	X	
Ramaria spp.		X	X	X	X	
Laccaria trichodermophora		X	X	X	X	
Russula xerampelina complex.		X	X	X	X	
Hypomyces lactifluorum		X	X	X	X	X
Hypomyces macrosporus		X	X	X	X	X
Infundibulicybe gibba		X	X	X	X	X
Lycoperdon perlatum		X	X	X	X	X
Russula brevipes		X	X	X	X	X
Russula delica complex.		X	X	X	X	X
Chroogomphus jamaicensis		X	X	X	X	X
Helvella crispa		X	X	X	X	X
Amanita amerifulva		X	X	X	X	X
Cantharellus aff. cibarius			X	X	X	X
Turbinellus floccosus			X	X	X	X
Hygrophorus chrysodon			X	X	X	X
Laccaria sp.			X	X	X	X
Tricholoma flavovirens			X	X	X	X
Amanita elongata			X	X	X	X
Ustilago maydis			X	X	X	
Hebeloma aff.mesophaeum			X	X	X	
Amanita rubescens complex			X	X	X	
Armillaria mellea complex			X	X		
Agaricus sp			X	X		
Infundibulicybe sp.				X	X	
Clavariadelphus truncatus				X	X	
Auricularia auricula-judae					X	X
Morchella snyderi						X

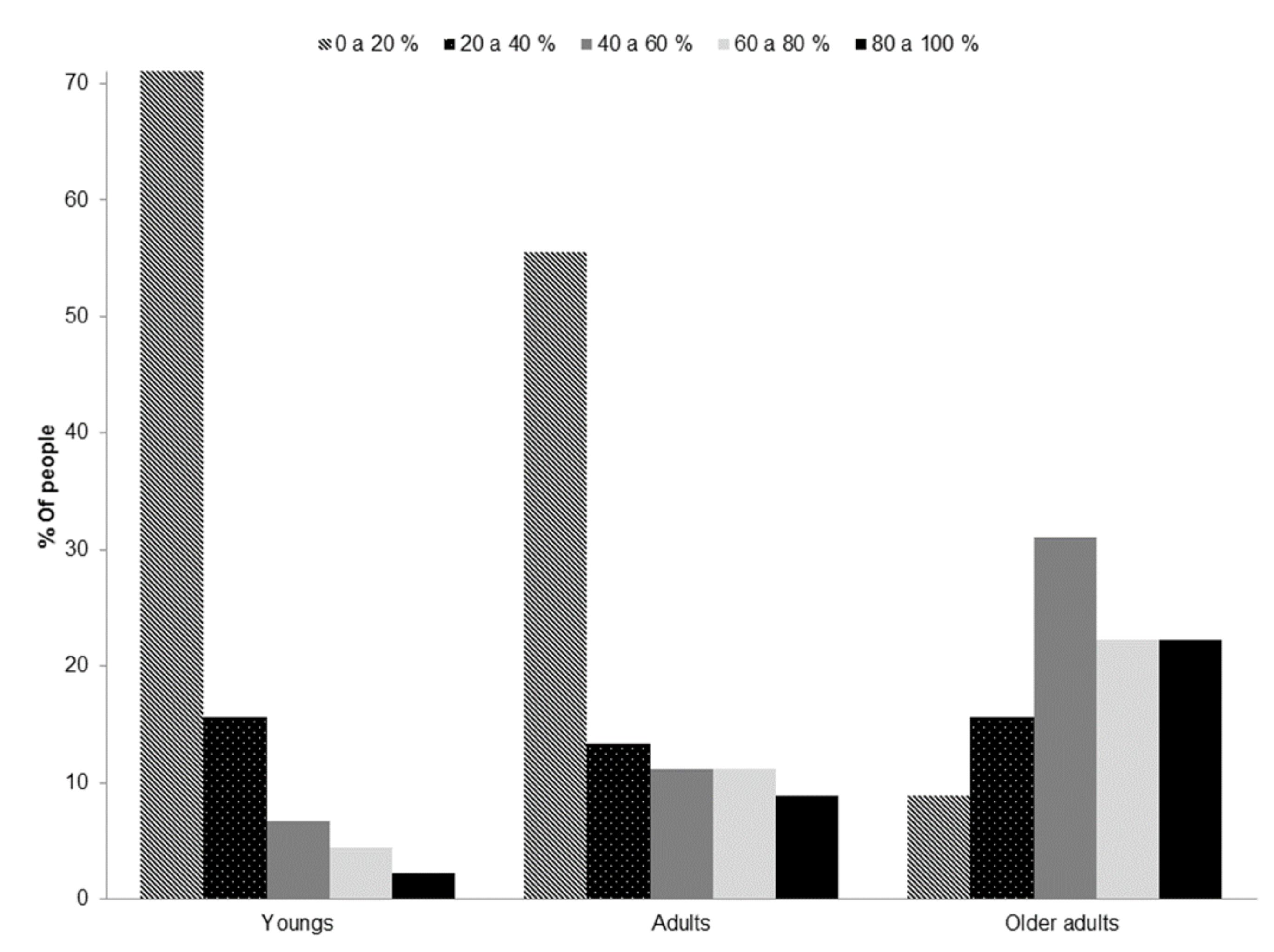

Figure 3. Percentage of people who identify the mushrooms referred to in each of the age categories.

not to harvest all of the mushrooms growing in an area; and another is that to collect them, then clean and shake them where they are picked to promote their dispersion. Only 42% of the respondents -- mostly people living in La Defensa – actually do this (Table 4).

Finally, when respondents considered the detailed relevance of wild mushrooms, they thought that they are important because they are food and they have ecological and economic value (Fig. 4).

Ethnotaxa and Bio-Cultural Significance Index

The result of the NMDS performed with a free listing of the mushrooms named by the respondents is acceptable (stress 0.13), the resulting ordination analysis shows a greater dispersion of the observations along axis 1, than the axis 2 (with values of between -1.6 to 3.35) (Fig. 5).

Ten more wild mushroom mentioned are ordered at the positive end of the axis 1, while rare mushrooms are found in the negative end. This order suggests a positive relationship between this axis and the diversity of mushrooms that people are familiar with (ethnotaxa index). Thus, high values on the one axis indicate knowledge of the greater diversity of wild mushrooms (Fig. 5).

As for the age of the interviewees, young people were found in the negative part of Axis 1, implying a lesser knowledge of ethnotaxa within this demographic age range. Older adults, regardless of where they live, are notably separated from young people, having positive rates of ethnotaxa, i.e., having a greater knowledge of mushrooms.

Where interviewees live is also a variable that has an impact on the grouping, with most of the La

Table 4. Wild mushroom relevance in the forest and traditional use in different areas of San Pedro Tlalcuapan and age groups.

Areas	Age group	Wild mushroom in the forest				Relationship mushroom/ plant	Traditional use		
		Fertilizer	Animal food	Seed	Desintegrator		Leave part of the mushroom	Leaves some mushrooms	Cleans out all the area
La Defensa	Youth	11	1	4	0	14	6	0	2
	Adults	8	3	8	0	13	10	1	3
	Old adults	8	1	7	0	15	11	0	2
La Iglesia	Youth	5	4	2	0	13	5	0	0
	Adults	6	2	9	1	14	5	2	0
	Old adults	8	2	7	0	14	5	0	1
La Colonia	Youth	6	7	2	0	11	3	0	0
	Adults	5	3	5	0	14	2	1	0
	Old adults	8	1	7	0	14	3	0	0

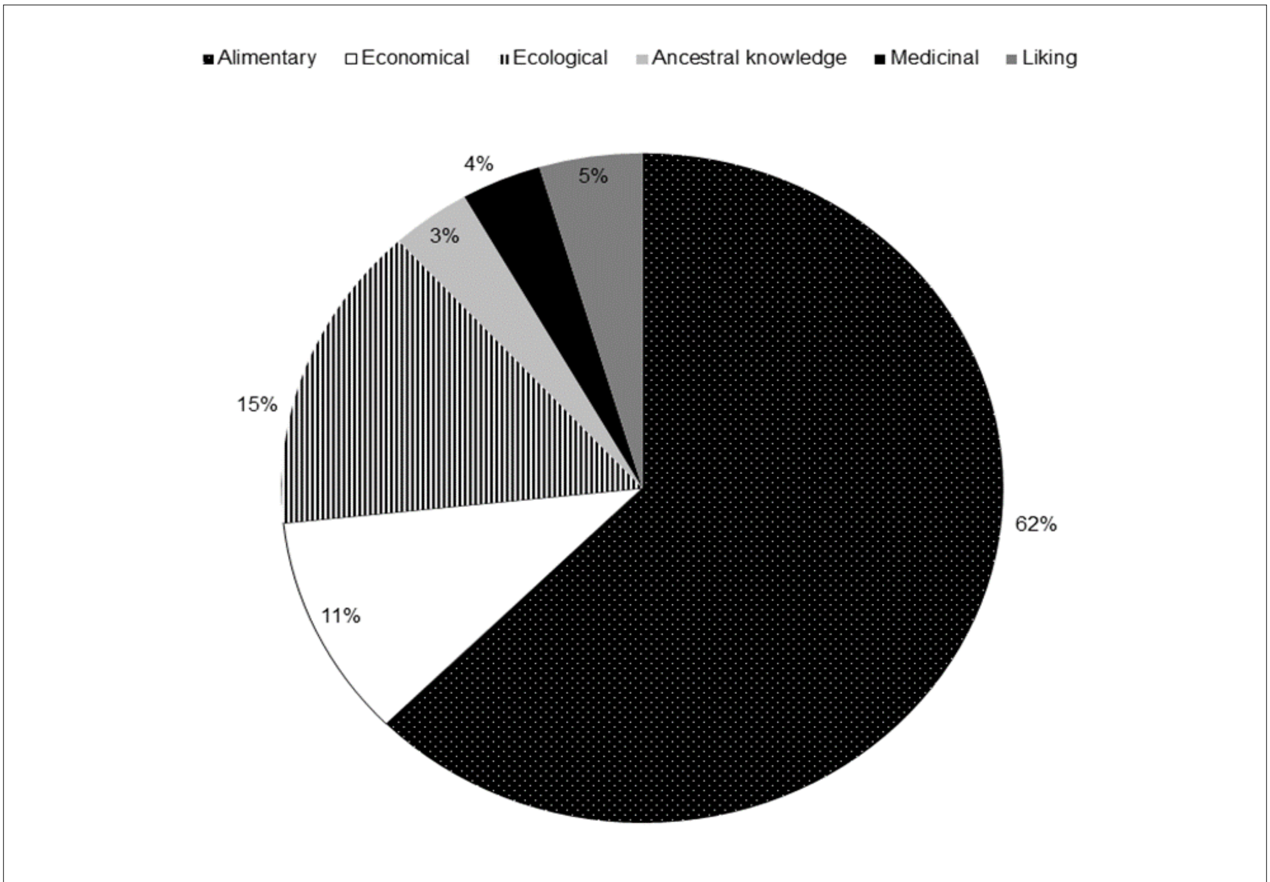

Figure 4. Importance of wild mushrooms for inhabitants of the community of Tlalcuapan.

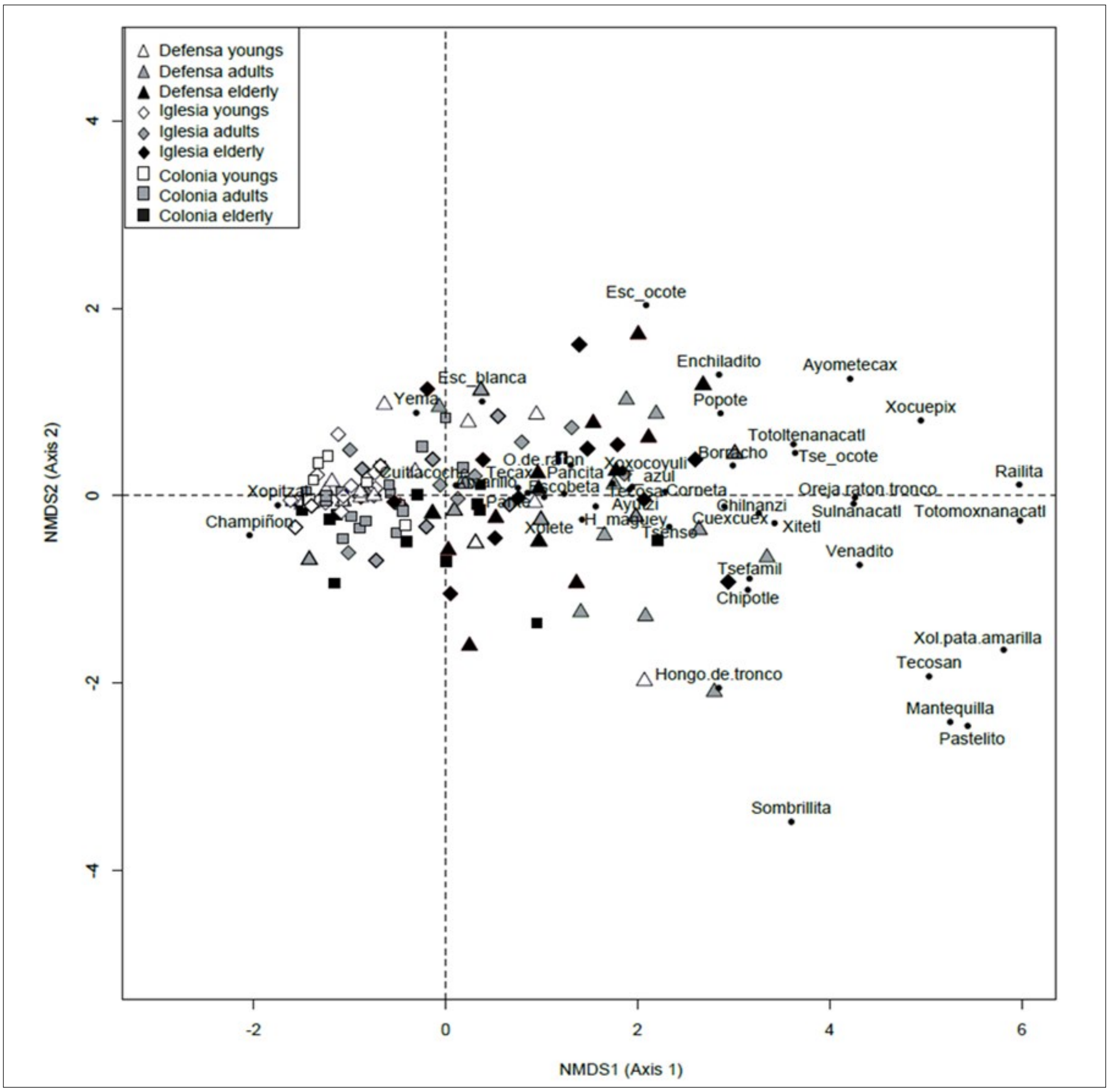

Figure 5. Non-metric multidimensional scaling (NMDS) that shows the distribution in the axis of the inhabitants of the different areas of SPT, according to their age category and its relationship with the regional diversity of mushroom. Triangles represent people from La Defensa, the diamonds to La Iglesia and squares to people of La Colonia. White makes reference to young people, gray to adults and black to older adults. The solid round dots allow to locate the ethnotaxa.

Defensa interviewees showing positive index values (between 0.003 and 3.34), corresponding to the interviewees who mentioned the majority of mushrooms. The people of La Colonia (values between - 1.6 and 0) know less about mushrooms including in their responses a cultivated white mushroom known as "el Champiñon". Because of this, they have a lower rate of ethnotaxa. Those who live in the area of La Iglesia have values ranging from - 1.6 and 3.09 as they share knowledge in both areas.

The NMDS applied to the data from the interviews on bio-cultural relevance is acceptable (stress 0.25), showing a greater variability associated with Axis 1, with values between - 1.5 and 3 (Fig. 6). Given the nature of the data, this analysis incorporates the importance and use of mushrooms.

The negative values of Axis 1 are a result of most of the variables related to ancestral knowledge and handling of the mushrooms, such as harvesting, consumption, forest functions and control strategies.

Three variables are located on the positive side of the Axis 1: purchase, disintegrator and animal food. For example, the people who buy mushrooms are put into a group that does not know where to find them or how to harvest them. As well, some consider mushrooms to be important only as food for animals and as a disintegrator in the forest and not as a useful resource for human beings.

It is observed that the variables that represent an extensive knowledge of mushrooms are grouped toward the negative side of the axis. Thus, a lower score on the axis of one of the variables of perception-based NMDS represents a greater bio-cultural relevance.

The majority of interviewees living in La Defensa are grouped in the negative part of Axis 1, which corresponds to a greater knowledge of mushrooms. The people of La Colonia, however, are grouped on the positive side, while the people of La Iglesia are mostly located in the middle part of the axis to correspond with their territorial location. With respect to the age groupings, there is no clear distribution the only age group that clusters together is the one comprising older people, which is located toward the negative side of the axis.

Change in Local Knowledge According to age and the Territory

The models of multiple linear regression were adjusted to explain ethnotaxa rates and bio-cultural relevance according to repondents' age and their area of origin. Both were significant (see Tables 5 and 6). According to the coefficients estimated for the ethnotaxa index, the index changed depending on the age of the respondent: the older he or she gets, the higher the rate of ethnotaxa index, being 0.03 the reason for the change. The ethnotaxa index also varies according to the area where a person lives: those living nearest to the forest will have a higher rate (see Table 5). Although the value of the contribution of each of the variables was significant ($p = 0.001$), the model presents a relatively low r2 ($r2 = 0.52$), indicating that the regression explains the pattern of the data, but does not have predictive power.

The index of bio-cultural relevance is also explained by age and where respondents live. The model indicates that this index changes with the age of the individual; the reason for change is - 0.005, i.e., on average an individual who is one year older than another will have a lower rate (lower than 0.005). Thus, older people tend to have the most negative relevance bio-cultural indices, which is confirmed with a reliability of 95%. The index of cultural relevance is also significantly related ($p = 0.01$) to the area where people live: according to the estimated coefficients, people living in La Colonia obtained a score of 0.66, for people that live in La Iglesia or in La Defensa decreased in 0.39 and 0.96 points, respectively (coefficients negative, Table 6). Therefore, the respondents who live nearest the forest will have a lower rate, i.e., a greater knowledge about mushrooms (Table 6).

Association Between the Indices

Regression analysis from the axis was significant (Fig. 7). According to the estimated coefficient, it suggests that for every unit of decline in the ethnotaxa index, there is a 1.05 increase in the value of the index of bio-cultural relevance ($p < 0.001$). While this regression significantly explains the contribution of relevant bio-cultural index values, the r^2 is relatively low ($r^2 = 0.37$), indicating that they do not have any predictive value. As shown in Fig. 7, there is abundant variability in the data. Both indices explain the

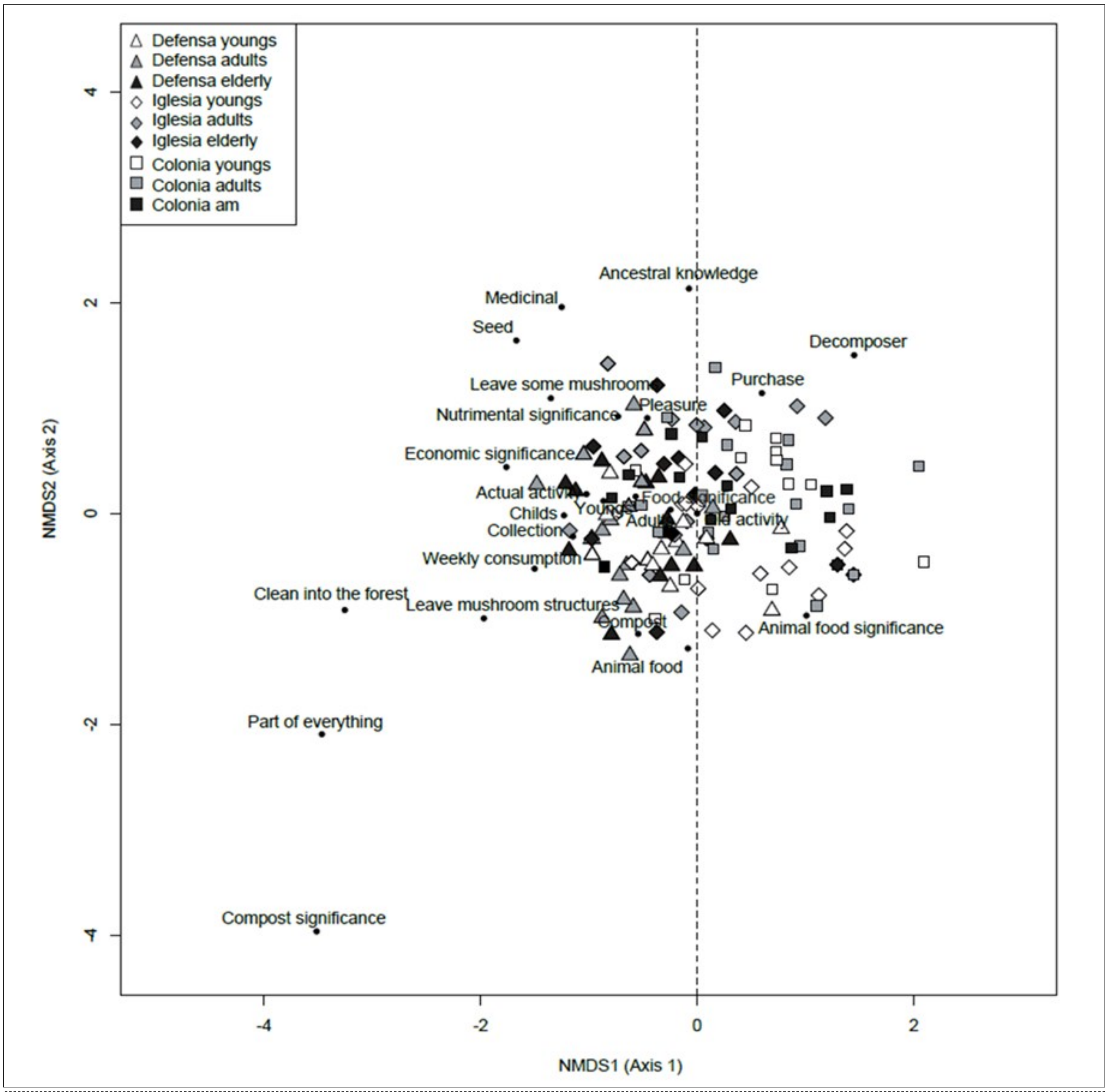

Figure 6. Non-metric multidimensional scaling (NMDS) showing the distribution on the axis of the inhabitants of the different areas of SPT, according to their age range and its relationship with mushrooms bio-cultural knowledge. Triangles represent people from La Defensa, the diamonds to La Iglesia and the squares to the people of La Colonia. White makes reference to young people, gray color to adults and black to older adults. The solid round dots allow to locate the ethnotaxa.

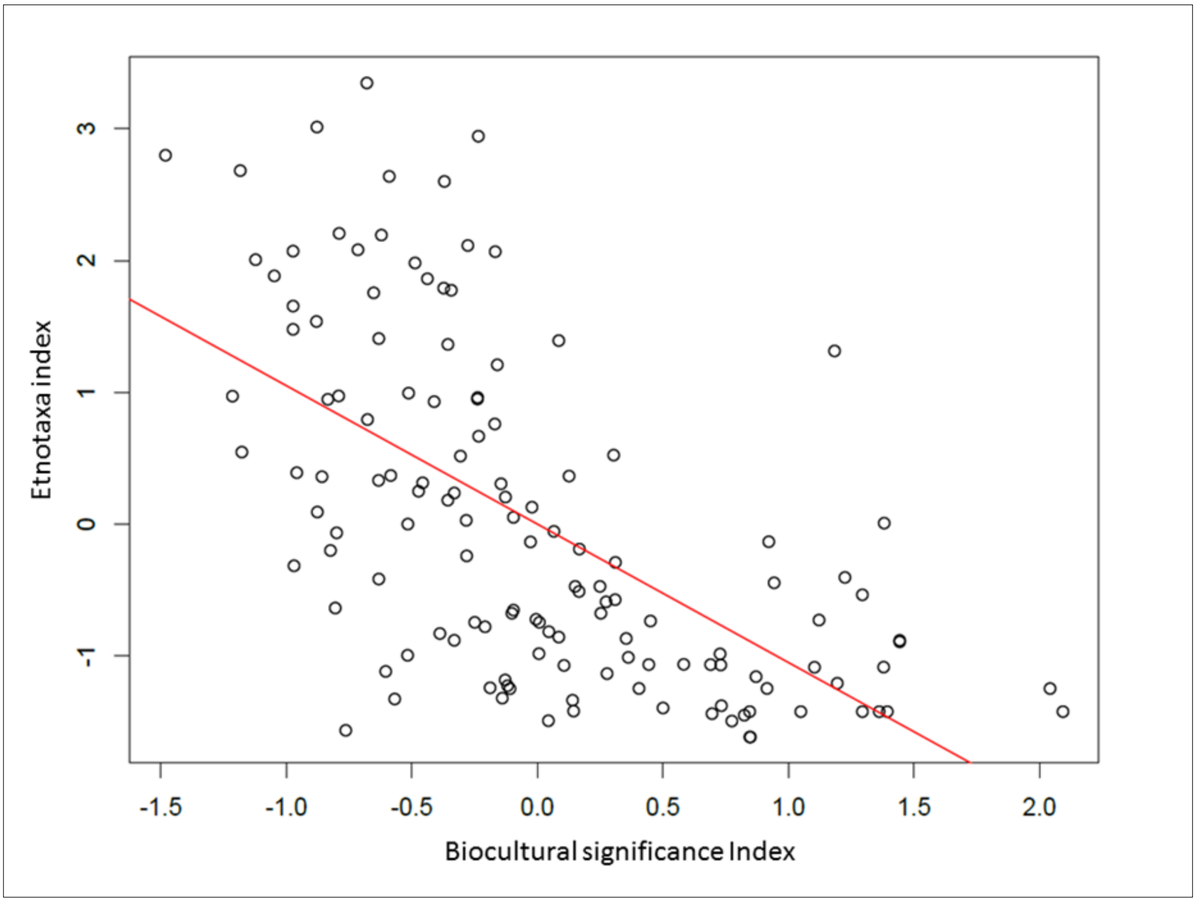

Figure 7. Regression on the index of ethnotaxa according to biocultural relevance, p index < 0.001, r^2 = 0.37.

Table 5. Multiple regression on the rate of ethnotaxa according to the place where respondents live and their according to their age.

	Estimated value	T Value	P Value
INTERCEPT	-1.94	-9.93	< 0.001
LA DEFENSA	1.57	8.29	< 0.001
LA IGLESIA	0.64	3.39	< 0.001
AGE	0.03	8.72	< 0.001
r^2= 0.52			

Table 6. Multiple regression on relevance of bio-cultural knowledge depending on where people live and their age index.

	ESTIMATED VALUE	T VALUE	MEANING
INTERCEPT	0.66	4.85	< 0.001
LA DEFENSA	-0.96	-7.28	< 0.001
LA IGLESIA	-0.39	-2.93	0.01
AGE	-0.005	-2.24	0.05
r^2= 0.31			

differences that exist in the ethnomycological knowledge between the age groups and where people live, but one finding cannot be predicted based on the other.

Discussion

The data obtained show that, in SPT, mushrooms are an important natural resource for the community, since the majority of the population identify and use them. The richness in the variety of names that are given to the wild mushrooms by specific ethnic groups is one of the indicators of the importance of these species, and the many traditional mushroom names correspond to a greater knowledge about their use and biology [29]. SPT has more useful mushroom species (50) than other communities situated on La Malinche [18, 19, 30]. Although they have reported about 15 to 30 species of mushrooms, the number of species in the community studied is similar to that reported for the Nahua community of San Isidro Buensuceso, where 48 species have been recorded [30].

Two of the species most frequently mentioned by respondents to this study (*Amanita basii* and *Boletus edulis* complex.) largely agree with those recognized as the most important in other communities of La Malinche, Tlaxcala and other regions of Mexico [19, 31, 32, 33]. This confirms the importance of these mushroom species in Mexico. The preference of *Russula delica* complex, is a special trait that distinguish to this community.

The majority of the people who consume edible wild mushroom mentioned in this study had been eating them for at least six months per year. Many of the respondents (mainly those who live in the two areas closest to the forest) obtain the mushrooms by harvesting them directly. This activity, as well as how the mushrooms are used, is still passed along from generation to generation. As is suggested by Boesch and Tomasello [34], this type of cultural transmission occurs between individuals of different generations, but within the same family (vertical transmission), for example, from parents to children. Furthermore, it is observed that this transmission is oral and hands-on, as mentioned by Luna-Morales [35], who showed that traditional knowledge has been generated, selected and accumulated collectively over thousands of years, and lives on in the memory and practices of the people and is mainly passed on through oral and hands-on communications.

The residents of SPT also recognize the roles that wild mushrooms play in the forest, such as providing fertilizer, seed for new growth and food for wild animals, so, the mushrooms are considered an important part of the natural environment in which they grow. This is confirmed because many of the interviewees noted that mushrooms are associated with trees and, over the years, they have used different methods to maintain their care.

Some studies in which traditional mycological knowledge is described mention that this knowledge varies depending on age [36, 37, 38, 23] and gender [19, 20, 21], however, in most of these studies they compare the number of fungi and uses that people enunciate, without considering other variables or statistical analyzes that allow identifying the differences between age ranges. An exception is that of Pacheco-Cobos et al. [20] who GPS-tracked the foraging pathways of 21 pairs of men and women from an indigenous Mexican community searching for mushrooms in a natural environment; measures of costs, benefits and general search efficiency were analyzed and related to differences between the two sexes in foraging patterns.

In this case, the two indices proposed in this study show significant differences in the knowledge about mushrooms depending on the age of, or the area inhabited by, the people of SPT. The EI is useful because it takes into account the mushrooms that everyone knows and not just their number allowing distinguishing those exclusive of certain age ranges. On the other hand, the BCSI considers different variables about uses, collection and mushroom ecology, that indicate the importance of the mushrooms as a resource, what facilitated knowing the knowledge distribution.

The age was an important factor in the level of knowledge, as it was observed in other studies [12, 15, 39,]. Regression analysis demonstrated that older people have a higher ethnotaxa index, i.e., they can identify the highest number of wild mushrooms in the area. But also a lower BCSI, which indicates that the elderly have a greater ecological knowledge, about collection and more uses than young people.

This situation could be explained by, as suggested by Garro [40], that age is associated with the natural process of the acquisition of knowledge, i.e., the greater the awareness in older adults is attributed to the greater opportunities they have had to learn, acquiring more experience and contact with the natural resources around them [15]. Also several studies have shown that the peak of acquisition of teoric knowledge, i.e. when this knowledge is similar to an adult, occurs at 10-15 years old [41, 42, 43], with an important increasing between 9-12 years old [44, 45, 46]. There are another factors affecting the acquisition process.

The fact the children and young people know less and participating less in these collection activities, indicate a loss in the transmission of mushroom knowledge, specially in La Colonia area. Eyssartier et al. [47], found that the transmission of traditional knowledge begins in early childhood, when children accompany their parents in cultivating the land. It appears, however, that, today, there are fewer opportunities for children to spend time with their parents, grandparents and others who know the practices and belives about conservation [48]. It has documented that formal education marginalizes local knowledge [14, 49], causing changes and promoting an urban life style [50, 12].

The study findings also suggest that lower level of knowledge among young people may be result of lack of interest in traditional knowledge, as young people – influenced by modernization -- may well consider this type of knowledge to be obsolete. It has, indeed, been demonstrated that older people are less affected by external influences than the young [13]. Young people tend to abandon their homes and ancestral customs as they focus their interests ton meeting the demands of Western culture [50].

The EI shows that people of each range age mention exclusive mushrooms, for example, Champiñon (*Agaricus bisporus*) is the most popular between young people. Yellow foot xolete (*Gymnopus dryophillus*) and Little cake (*Russula xerampelina* complex) were named only by adults, whereas the Ayometecax (*Lactarius salmonicolor*), Tzunanacatl (*Macrolepiota* aff. *procera*) and Xocuepix (*Helvella crispa*) were mentioned by older adults.

Significant differences were observed between the three areas of the community. The BCSI, permitted the observation that most of the people living the furthest away from the forest have less mushroom knowledge, since them do not collect, eat fewer of them and buy the mushroom what they do eat. They do not know where the mushrooms grow or how to take care of them. Because these people live in an urban area, they seem to think it easier to go to the grocery store to buy the farmed white mushrooms (Champiñon) than to go to the forest to look for the wild ones. Bonilla-Moheno and García-Frapolli [51] as well as, Reyes-García et al. [52] mention that the integration to the Market is an important factor that modifying traditional knowledge because people who can pay these kind of market products, substitute the forests products, making traditional knowledge irrelevant. Most of the people living in La Defensa close to the forest eat mushrooms which they themselves have picked, which increases local knowledge about mushrooms, where they grow, what season they appear and their uses. In addition, the majority says that it is a complementary activity to their daily work in agriculture, involving the whole family. Other authors have noted this also [14, 15] people who work with the environment are able to maintain a greater knowledge of mushrooms than those who do not.

For La Defensa residents, it is more economical and rewarding to get food from the mountain instead of going to the supermarket in the city, since that would incur major expenses. Many people said "we do not know the quality of what we buy and, in the forest, everything is clean and healthier." This is why they continue eating wild mushrooms.

The people of La Iglesia share both perceptions. Although the regression analysis indicates that each area has a different view of wild mushrooms, it confirms that the distance of housing from the forest has a significant impact on traditional knowledge. This indicates that there is a loss of mycological knowledge among people who live far from the forest and closer to the city.

While the bio-cultural relevance index includes more variables analyzed and, therefore, raises several questions, both indices were useful for achieving the objectives of this study, allowing the comparison of mushroom knowledge among local sites in the community and age groups. In addition, this study makes a methodological contribution since it can be replicated in any other community or group of communities. It must be taken into account, however, that neither of the indices can predict the outcome of the other. So future studies need to establish clear objectives and decide which index to use or perhaps develop one that it encompasses both objectives, since these data are independent.

Conclusions

SPT is a community in which currently the wild mushroom are a resource of great importance; however, previous analyses, and as authorities and residents of SPT have stated, there is a risk that traditional wild mushroom knowledge will vanish, as it seems to be restricted to only a part of the community's territory and to particular age groups, indicating that there is a fragmentation in the transmission of knowledge from generation to generation. This study will allow researchers to focus on how to better disseminate this knowledge to the vulnerable age groups and suggest strategies of strengthening the transmission of this knowledge to other age groups and/or territories.

On the other hand, the proposed indices facilitate the evaluation of the variables associated with the distribution of traditional knowledge and allow comparisons among different areas of study. These are also flexible, since the bio-cultural variables can be included or eliminated and adjusted to different cultures or natural resources.

Authors' Contributions

EB-C designed the study, carried out the field work, the analysis and interpretation of data and wrote the manuscript. AC-M made substantial contributions to the analysis and interpretation of data. RIT-V, AM and JC participated in the design of the study, and the revision of the document. All authors read and approved the final manuscript.

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