



Mycophilic Degree among the Wixaritari and Mestizos in Villa Guerrero, Jalisco, Mexico

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ABSTRACT

The appreciation and taste towards mushrooms are influenced by sociocultural factors and ecological variables. This study evaluated the mycophilic degree among the Wixaritari and mestizo communities in a municipality in the north of Jalisco, settled in different types of vegetation, to determine if ecological and sociocultural factors influence the attitude towards the mushrooms. The Mycophilia-Mycophobia Index was evaluated in 10 communities in which structured interviews were conducted with a representative number of people. Responses to 18 indicators were analyzed by statistical tests. In general, the population resulted mycophilic. There were significant differences between the Wixaritari and mestizo attitudes in 10 of the 18 indicators. The model that best explained the mycophilic attitudes was community-cultural group in which the vegetation type was involved. Nevertheless, the cultural group alone affected the perception towards some issues, as the indicators include here have shown. One Wixarika community in pine-oak forest was extremely mycophilic, in contrast to a mestizo community in oak forest that was indifferent to the mushrooms; these attitudes were the result of historical events that have modified the lifestyle of people. The differences in the evaluated indicators were due to the cosmovision of each cultural group. Changes in lifestyle and diet have caused a lack of interest and an apathetic attitude towards wild mushrooms in a community, but the farthest communities showed a greater appreciation towards mushrooms, especially since these and the rest of the wild resources are used to meet their basic needs. These attitudes could have implications for biological conservation because of the appreciation of a strong dependence on the environment.

Keywords: Edible Wild Mushrooms; Ethnomycology; Huichol; Wixarika.

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INTRODUCTION

Mushrooms are organisms that provoke different feelings and attitudes in people, from fear and disgust in some persons to joy and affection in others, which have been named mycophobic and mycophilic attitudes,

respectively (Ruan-Soto et al. 2013; Wasson and Wasson 1957). These positions towards mushrooms are at the extreme ends since there are many stances that can fall in between, such as disinterest, apathy, or the ignorance of their existence (Ruan-Soto et al. 2013).

There are many factors that can influence these behaviors, like the culture of the group of people in question, as well as their life history. López-Austin (2004) proposed that the traditions, lifestyle, and activities of a society transform and adapt the ideas, conceptions, and perceptions of each individual and the way that they relate with biotic or abiotic elements. Attitudes towards mushrooms can also be related with socio-economic besides cultural factors (Garibay-Orijel *et al.* 2012; Montoya *et al.* 2012; Pérez-Moreno *et al.* 2008). For instance, in the case of mushrooms, Ruan-Soto *et al.* (2013) found that the degree of mycophilia is not related to the ecological region but is instead mostly affected by sociocultural factors such as gender, cultural group, occupation, or the origin of the people. In contrast, Mapes *et al.* (2002) suggested that mycophilia or mycophobia were not associated only to cultural factors, but also others such as ecological variables (e.g., vegetation type) had an influence and might cause differences within the same culture about the importance assigned to mushrooms. When a cultural group colonizes new places with different types of ecosystems, they may or may not take advantage of the mushrooms that belong to this new environment. Thus, they could change their conceptions related to these new species and, due to this, their degree of mycophilia would change over time (Arora and Shepard 2008; Mapes *et al.* 2002).

It is known that people with mycophilic attitude has a higher traditional knowledge on its ecosystems, in this case specifically mushrooms, encouraging them to a better conservation of their environment (Ruan-Soto *et al.* 2013). On the other hand, certain patterns can be observed in the traditional mycological knowledge and in the practices related to using wild mushrooms. Usually, women were the ones who know the most

about mushrooms and were the main transmitters of this knowledge (Garibay-Orijel *et al.* 2012; Montoya *et al.* 2012). In addition, this was better preserved in the communities settled near forested areas, where there was a greater availability of resources (Burrola-Aguilar *et al.* 2012; Villarreal and Pérez-Moreno 1989). Although in rural areas in Mexico, the mestizos make use of wild mushrooms (Mariaca *et al.* 2001; Moreno-Fuentes 2013; Ruan-Soto *et al.* 2006), it has been considered that the indigenous population tends to preserve a greater heritage of knowledge about mushrooms (Guzmán 2008; Pérez-Moreno *et al.* 2008).

One of the 68 ethnic groups of Mexico that has attracted much attention from various researchers has been the Huichol or Wixarika. This group, despite having suffered abuse from the oppression, discrimination, and violence, has a great capacity of self-affirmation and strong syncretism (Diguet 1899; Neurath 2002). The Wixarika's cosmovision is contradictory because several realities can exist simultaneously. It agrees with the chaos, it does not distinguish between good and evil, nor separates nature and society from magic and religion (Neurath 2005; Neurath and Pacheco 2011; Villegas 2016). In any of the interpretations of the tangible and intangible world, there are variations and changes at distinct levels within and among the communities, especially in their ritual practices (Kindl 2003).

Anthropological and ethnographic studies have reported Wixaritari consuming mushrooms to cope with periods of scarcity (Lumholtz 1902; Neurath and Pacheco 2011). Furthermore, anthropolinguistic and ethnobotanical studies have listed names of edible (Bauml 1989, 1994; Grimes 1980; Price 1967) and some toxic (Torres 2000) mushrooms in the Wixarika language. Until

now, the only ethnomycological works on the Wixaritari are Villaseñor-Ibarra *et al.* (2018) and Haro-Luna *et al.* (2019), who reported the relationship of this cultural group in the communities Tateikie and Villa Guerrero, with 20 and 36 species of wild mushrooms, respectively. In comparison, mestizo population of Villa Guerrero only know 14 species (Haro-Luna *et al.* 2019).

The municipality of Villa Guerrero, at the North of Jalisco, Mexico, has Wixaritari and mestizo communities near pine and oak forests, and others near subtropical scrub. According to Bello-Cervantes *et al.* (2019), the persons in the communities closest to the forests where there is a greater biological diversity of sporomes have a better relationship with the mushrooms. And following the above mentioned that the indigenous groups, as well as the women, retain a greater ethnomycological knowledge, our objective was to carry out a comparative study of the degree of mycophilia-mycophobia present in the population of a multicultural municipality where Wixarika—an indigenous group—and mestizo—mixture of various cultures, including European—people converge. We proved the hypothesis that the Wixaritari had a higher degree of mycophilia compared to the mestizo population in Villa Guerrero, Jalisco, Mexico. Likewise, we explored the possibility that other socio-demographic or ecological factors, such as gender or vegetation type, can better explain the attitude that people have towards mushrooms. With this information, we can recognize the cultural group, and the factors around it, that have a better relationship with mushrooms and that are aware of the ways to make use and maintenance of non-timber resources such as mushrooms (Ruan-Soto *et al.*, 2013).

MATERIAL AND METHODS

Study area

This study was carried out in 10 communities in the municipality of Villa Guerrero, in the northern part of the state of Jalisco, Mexico (Figure 1). Three of these communities belong to the Wixarika group, five are mestizo communities, and two have people from both cultural groups that live together (Table 1). In these communities, mushrooms are a wild resource with cultural and nutritional importance (Haro-Luna *et al.* 2019). In the municipality, the semi-warm semi-dry and semi-warm sub-humid tempered climates predominated. In the region, the average annual temperature was 18.7 °C and the average annual rainfall of 803.2 mm, throughout the months of June to September. The elevation varies from 980 to 2360 m a.s.l. (INEGI 2019). The terrain is extremely rugged but allow the development of diverse types of vegetation such as pine-oak forest, oak forest, and subtropical scrubland, as well as grasslands by human activities, such as land-clearing of areas destined for livestock and agriculture. In the region, the oak forest is very fragmented, also due to human activities (IIEG 2019; INEGI 2019; SEMARNAT 2005).

The municipality is categorized by the Mexican government as a region with a low degree of connectivity in roads and highways. Most of its communities are located inside of the Sierra Madre Occidental, among canyons and ravines, thus they are kept uncommunicated most of the time. The basic economic activities are rainfed agriculture and extensive cattle raising for local consumption and export. Nevertheless, other practices are also carried out such as fishing and the use of wild resources to complement their diet and

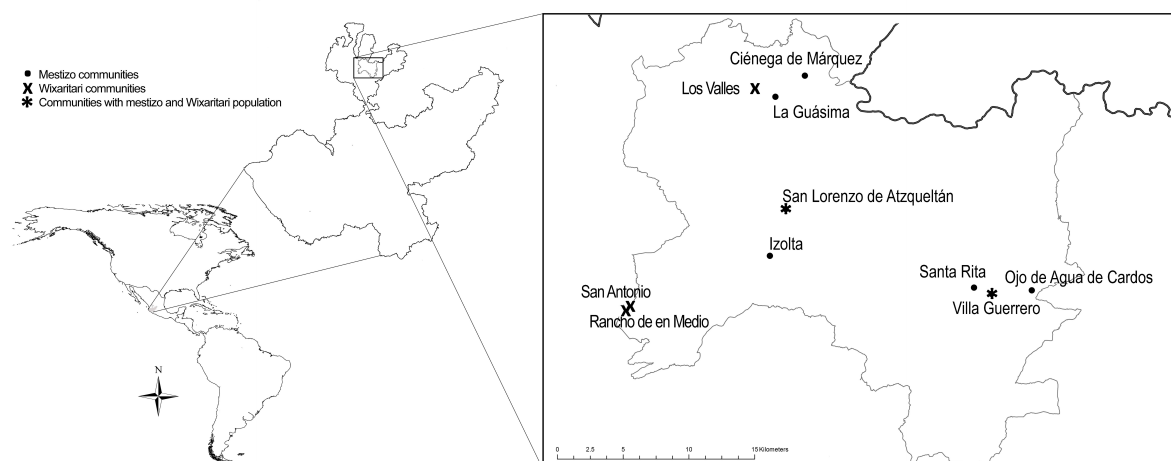


Figure 1. Communities studied in Villa Guerrero, Jalisco, Mexico.

Table 1. Communities in which the interviews were conducted, cultural group to which they belong, and number of interviewees in the municipality of Villa Guerrero, Jalisco, Mexico.

Community	Vegetation type	Cultural group	Number of interviewees
Ciénega de Márquez	Subtropical scrub	Mestizo	21
Izolta	Subtropical scrub	Mestizo	34
La Guásima	Subtropical scrub	Mestizo	33
Los Valles	Subtropical scrub	Wixarika	20
Rancho de en Medio (Manillas)	Pine-oak forest	Wixarika	23
Ojo de Agua de Cardos	Oak forest	Mestizo	41
San Antonio	Oak forest	Wixarika	20
San Lorenzo de Atzqueltán	Subtropical scrub	Wixarika & mestizo	13/57*
Santa Rita	Subtropical scrub	Mestizo	47
Villa Guerrero	Subtropical scrub and oak forest	Wixarika & mestizo	46/99*

*Number of Wixaritari/number of mestizos.

to have a source of income on a smaller scale. The municipality has a high migration rate as a consequence of the high levels of poverty (INEGI 2019; Shadow 2002).

Data collection and analyses

A total of 454 structured interviews were

carried out at random to a representative number of people above 15 years old in each community, calculated with the sample size (SS) formula $SS = Z^2 \cdot p \cdot (1-p) / C^2$, where the margin of error was 5%. This work has been adhered to the stipulations of the ethics code of the Latin American Society of Ethnobiology (SOLAE) (Cano-Contreras et

al. 2015). Thus, in addition to managing a general authorization in every community, we verbally requested permission from each person before conducting the interview, as well as their consent to use their information for this study.

Interview formats contained questions that tackled each of the cultural domains and indicators proposed by Ruan-Soto *et al.* (2013) (Table 2) to evaluate the degree of mycophilia-mycophobia. It was applied one question per indicator —except in some cases, where two were done to make the question clearer—, as well as questions to gather the socio-demographic information (community, age, cultural group, occupation, gender) of each interviewee. The value of the mycophilia-mycophobia index was calculated based on Ruan-Soto *et al.* (2013), where the score obtained for each of the 18 indicators was added up. Responses to each indicator were coded with a value of 1 for a positive attitude, 0.5 neutral attitude, and 0 for a negative attitude. If the sum of all the indicators was 0, it was considered as an extreme mycophobic attitude, whereas a score of 18 as an extreme mycophilic attitude.

In addition, in-depth interviews, described by Robles (2011), were conducted with a total of 12 quality informants —people who are identified by the community as those who know more about mushrooms—, who were inhabitants of each community, except for the case of the two multicultural communities where a person from each cultural group was interviewed. In this technique, there is no formal exchange of questions and answers, but an intimate talk is established during several sessions in which topics of interest are gradually being addressed. These interviews helped to clarify the conceptions, ideas, and perceptions of each cultural group. Answers

of the structured interviews were recorded in the pre-established formats and responses to in-depth interviews, besides the reactions and extra data, were registered in the field diary, as well as audio and/or video recordings when the interviewee's consent was obtained. The collection of these data was carried out over two years of field work, from Feb 2016 to Mar 2018.

In the analyses of the quantitative data, first we carried out frequency distributions, contingency tables, and χ^2 tests to find significant differences among the values of the responses in each of the 18 indicators between cultural groups and between men and women (Ruan-Soto *et al.* 2014).

To explore the existence of grouping patterns by ecological or sociocultural variables, cluster analyses were done, and distance matrices were calculated with the average taxonomic distance method. In addition, principal components analysis (PCA) was performed with the average values of each indicator per community-cultural group (Ruan-Soto *et al.* 2013). These multivariate techniques were carried out with NTSYS 2.11x (Numerical Taxonomy and Multivariate Analysis System).

Four models were constructed using a beta probability-density function with maximum likelihood adjustment to evaluate which factors (community, gender, or cultural group) better explain the distribution of attitudes toward mushrooms in the population (Ruan-Soto *et al.* 2013). The four models could be put in the categories of: (i) null model; (ii) one-factor model: gender, cultural group; (iii) two-factor models: community-cultural group. Each of these models was compared with the Akaike Information Criterion (AIC) to determine which was best supported by the data.

Table 2. Indicators and questions applied in structured interviews about the mycological knowledge to Wixaritari and mestizo communities in Villa Guerrero, Jalisco, Mexico.

Indicator	Question
1. Recognition of edible species	Do you know any edible mushrooms?
2. Traditional taxonomic knowledge of edible species	How do you know that a mushroom is edible?
3. Harvesting practices	How do you collect mushrooms?
4. Consumption of edible species	Do you eat mushrooms?
5. Appreciation of mushrooms as food	Do you like to eat mushrooms?
6. Culinary knowledge	Do you know how to cook mushrooms?
7. General attitude towards edible species	Do you like the edible mushrooms or distrust them?
8. Recognition of the existence of toxic species	Do you know any toxic or poisonous mushrooms?
9. Morphological knowledge of toxic species	How do you recognize an edible mushroom from one that is not?
10. Attitude toward species without cultural significance	Do you feel afraid to approach or touch a toxic mushroom? What do you do with a non-edible mushroom?
11. Existence of tales or myths of origin that include mushrooms	Do you know how mushrooms were created? Why do mushrooms appear?
12. Other uses besides food	Do you know mushrooms that can be used as something other than food?
13. Existence of specialists in harvesting or salespeople of mushrooms	Do you know of someone who sells mushrooms?
14. Knowledge of the role of mushrooms in the ecosystems	Why are mushrooms important in nature?
15. Knowledge of the relationship between mushrooms and animals	Do mushrooms have any relationship with animals? Do animals eat mushrooms?
16. Existence of knowledge transmission mechanisms	Have you taught someone to recognize, collect, and/or cook mushrooms?
17. General attitude towards mushrooms as a whole	In general, do you like or feel afraid of edible or toxic mushrooms, or do you not care?
18. Perceived importance of mushrooms as a group	Will something happen if all mushrooms disappear?

RESULTS

When comparing the results, about positive, neutral and negative responses of the Wixaritari and mestizos, it was found that there were significant differences in 10 of the 18 indicators (test χ^2 , $p < 0.05$). These 10 indicators were (number following Table 2, and statistical significance): traditional taxonomic knowledge of edible species (2,

$p=0.00$), harvesting practices (3, $p=0.00$), recognition of the existence of toxic species (8, $p=0.025$), morphological knowledge of the toxic species (9, $p=0.01$), attitude toward species without cultural importance (10, $p=0.04$), other uses besides food (12, $p=0.00$), existence of specialists in collection or salespeople of mushrooms (13, $p=0.00$), knowledge of the role of mushrooms in the ecosystem (14, $p=0.005$), knowledge of the relationship between mushrooms and animals (15, $p=0.00$), and existence of

knowledge transmission mechanism (16, $p=0.00$). In general, the Wixaritari presented a higher frequency of positive attitudes in all indicators, except in indicator 13 'existence of specialists in collection or salespeople of mushrooms', where they had more negative answers and mestizos had more positive

responses.

Both groups had a generally positive attitude for the eight indicators in which there was no significant difference (test χ^2 , $p>0.05$), which were: recognition of edible species (1, $p=0.35$), consumption of edible species (4, $p=0.1$), appreciation of

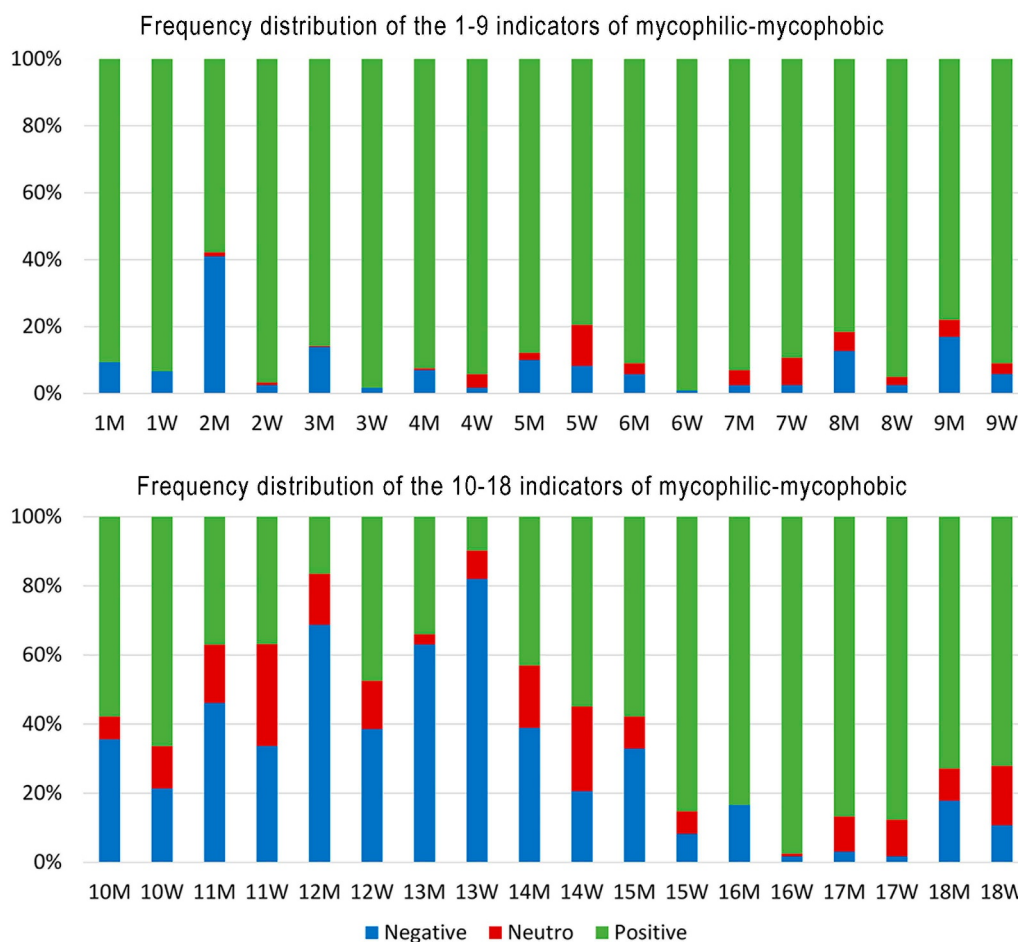


Figure 2. Frequency distribution of the 18 indicators of mycophilic-mycophobic degree of Wixaritari and mestizo interviewees in the municipality of Villa Guerrero, Jalisco, Mexico. W: Wixaritari, M: mestizos. The numbers mean 1. Recognition of edible species; 2. Traditional taxonomic knowledge of edible species; 3. Harvesting practices; 4. Consumption of edible species; 5. Appreciation of mushrooms as food; 6. Culinary knowledge; 7. General attitude towards edible species; 8. Recognition of the existence of toxic species; 9. Morphology knowledge of the toxic species; 10. Attitude toward species without cultural significance; 11. Existence of tales or myths of origin that include mushrooms; 12. Other uses besides food; 13. Existence of specialists in harvesting or salespeople of mushrooms; 14. Knowledge of the role of mushrooms in the ecosystem; 15. Knowledge of the relationship between mushrooms and animals; 16. Existence of knowledge transmission mechanisms; 17. General attitude towards mushrooms as a whole; 18. Perceived importance of mushrooms as a group.

mushrooms as food (5, $p=0.35$), culinary knowledge (6, $p=0.06$), general attitude towards edible species (7, $p=0.5$), existence of tales or myths of origin that include mushrooms (11, $p=0.5$), general attitude towards mushrooms as a whole (17, $p=0.5$), and perceived importance of mushrooms as a group (18, $p=0.35$).

Ordination and classification according to the attitude towards mushrooms

The ordination and classification tests showed that two large groups of communities were formed and one of the mestizo communities (Ojo de Agua de Cardos) was left out of the groups. One group was composed mostly of the Wixaritari populations (San Antonio, San Lorenzo, Rancho de en Medio, Villa Guerrero) and two mestizo settlements (Ciénega de Márquez, La Guásima). The other group was composed mostly of mestizo communities (Izolta, San Lorenzo, Santa Rita, Villa Guerrero) and only one Wixarika (Los

Valles), as it can be seen from the cluster analysis (Figure 3).

The principal components analysis (Figure 4) showed that the principal component 1, which explained 49.50% of the variation, discriminated the mestizo population Ojo de Agua de Cardos from the rest. The most important characteristics were the existence of harvesting practices (3, see Table 2) and the existence of knowledge transmission mechanisms (16). The principal component 2, which explained 16.56% of the variation, discriminated the mestizo communities of Izolta, San Lorenzo, Santa Rita, and Villa Guerrero, and the Wixarika settlement of Los Valles from the rest of the Wixaritari communities, where the existence of specialists in harvesting or salespeople of mushrooms are unknown (13), as well as settlements in which most people had knowledge about characteristics to recognize toxic mushroom species (9).

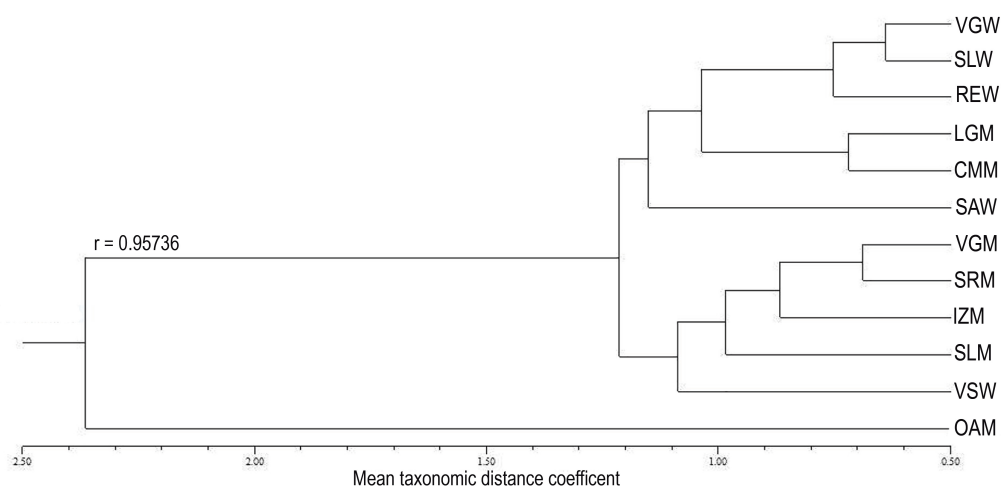


Figure 3. Cluster analysis by community-cultural group in a study of the mycological knowledge of Wixaritari and mestizo communities in the municipality of Villa Guerrero, Jalisco, Mexico. The first two letters correspond to the community, CM: Ciénega de Márquez; IZ: Izolta; LG: La Guásima; OA: Ojo de Agua de Cardos; RE: Rancho de en Medio; SA: San Antonio; SL: San Lorenzo de Atzqueltán; SR: Santa Rita; VG: Villa Guerrero; VS: Valles. The third letter corresponds to the cultural group, W: Wixarika; M: mestizo.

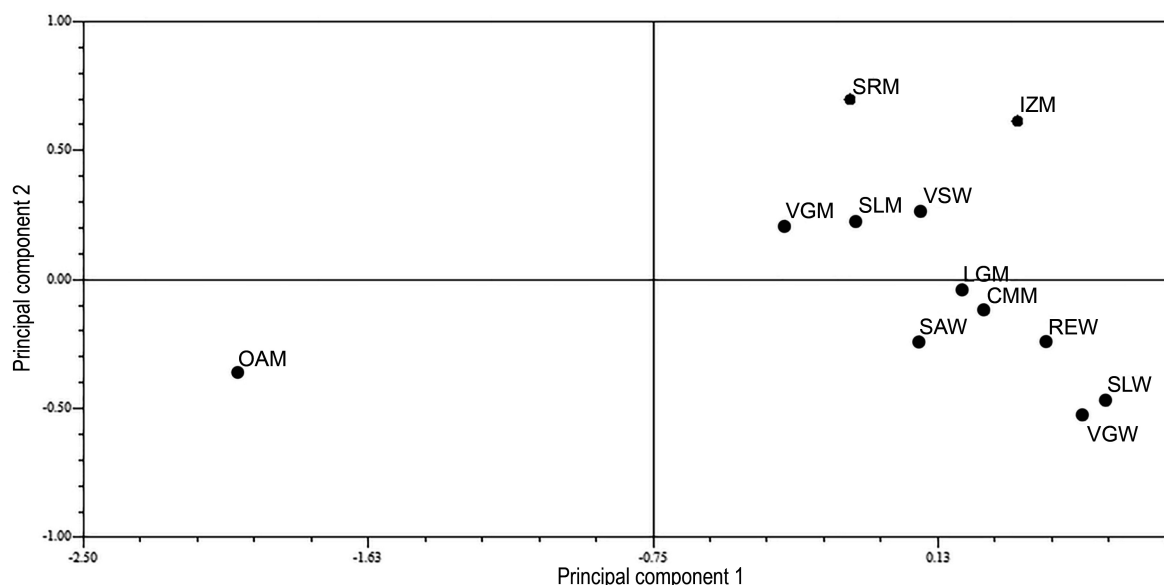


Figure 4. Principal components analysis (PCA) community-cultural group in a study of the mycological knowledge of Wixaritari and mestizo communities in the municipality of Villa Guerrero, Jalisco, Mexico. The first two letters correspond to the community, CM: Ciénega de Márquez; IZ: Izolta; LG: La Guásima; OA: Ojo de Agua de Cardos; RE: Rancho de en Medio; SA: San Antonio; SL: San Lorenzo de Atzqueltán; SR: Santa Rita; VG: Villa Guerrero; VS: Valles. The third letter corresponds to the cultural group, W: Wixarika, M: mestizo.

Probability distribution of the Mycophilia-Mycophobia Index

In general, people from the municipality of Villa Guerrero had a tendency towards mycophilic attitudes (Figure 5a); however, there was a greater probability of finding Wixarika people with a high mycophilic degree than mestizo people (Figure 5b). Although there was a greater possibility to find extremely mycophilic women in both groups (Figure 5c).

There was a greater number of extremely mycophilic people in a Wixarika community in pine-oak forest (Rancho de en Medio) and in a multicultural community settled in scrubland and oak forest (Villa Guerrero), followed by a mestizo settlement in a subtropical scrubland (Izolta) (Figure 5d). In the two multicultural communities, there was a higher probability of finding Wixaritari than mestizos with a higher mycophilic degree (Figure 5d). The adjusted probability

distribution of the mestizo community Ojo de Agua de Cardos, in oak forest, did not present a bell shape because they did not exhibit a mycophobic or mycophilic tendency (Figure 5d).

The comparison of models through the AIC values showed that the model that best explained the distribution of data was the two-factor model: community-cultural group (Table 3). According to the value of AIC the gender model lacks any explanatory or predictive power followed by the null mode and cultural group model.

DISCUSSION

In general, the population interviewed presented a mycophilic attitude. In Mexico, it was previously thought that mycophilic people were mostly concentrated in temperate zones at the center of the country because it is in this region where a greater number of species are consumed and the

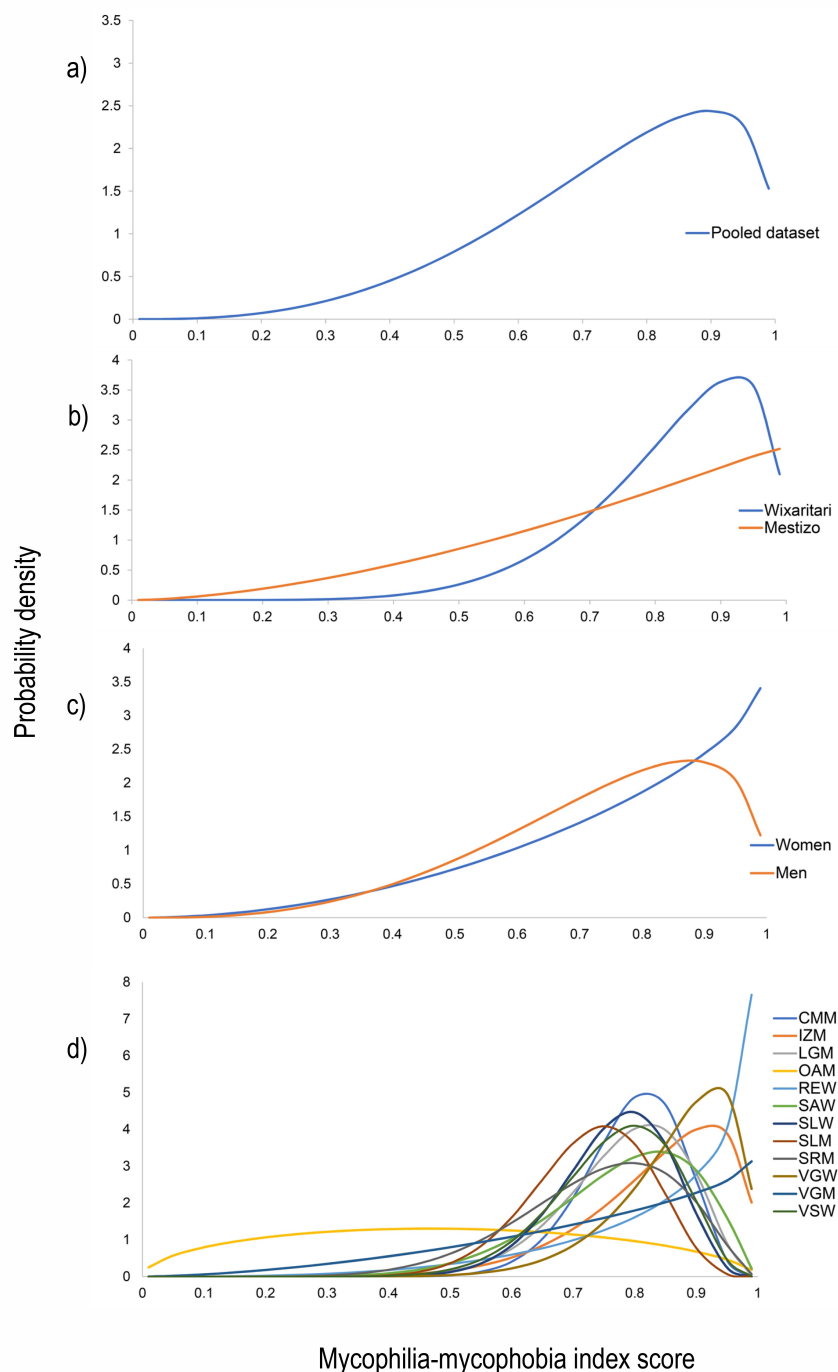


Figure 5. Probability distribution of the mycophilic-mycophobic index of Wixaritari and mestizo communities in the municipality of Villa Guerrero, Jalisco, Mexico, with the different models tested: a) Null model (total data); b) One factor model: gender; c) One factor model: cultural group (Wixaritari-mestizo); d) Two factors model: community-cultural group. The first two letters correspond to the community, CM: Ciénega de Márquez; IZ: Izolta; LG: La Guásima; OA: Ojo de Agua de Cardos; RE: Rancho de en Medio; SA: San Antonio; SL: San Lorenzo de Atzqueltán; SR: Santa Rita; VG: Villa Guerrero; VS: Valles. The third letter corresponds to the cultural group, W: Wixarika, M: mestizo.

Table 3. Akaike Information Criterion (AIC) values for the compared models in a study of the mycological knowledge of Wixaritari and mestizo communities in the municipality of Villa Guerrero, Jalisco, Mexico.

Model	AIC
Community-cultural group	-613.77
Cultural group	-418.38
Null model	-403.68
Gender	-390.09

harvest and sale of mushrooms represent a significant economic income for people (Burrola-Aguilar *et al.* 2012; Mapes *et al.* 2002; Montoya *et al.* 2008; Moreno-Fuentes and Garibay-Orijel 2014; Moreno-Fuentes *et al.* 2001). Nevertheless, Ruan-Soto *et al.* (2006, 2013, 2014) realized that also in southern Mexico the population is generally mycophilic, even in tropical lowlands where mushrooms are also consumed and use in different manners. The present study also proved that in a semi-arid region with small forested areas (subtropical scrub and oak forest), located at the Mesoamerican northern border, the general population was mycophilic. As in the study by Ruan-Soto *et al.* (2013), this attitude did not exclude mycophobia, but behaves rather as a gradual scale, i.e., the people in the study area presented either positive or negative postures to the different indicators.

The increase in studies in regions where ethnomycological data is not yet available, will allow to find the use of mushrooms by different populations that were thought to be mycophobic and where the mycophilic attitude was not documented. And even in populations where mushrooms are not used, we could assume that mycophobia would not be extreme, especially because of globalization and the insertion of products, mainly foods, that contain mushrooms. These cultural insertions of mushrooms in some dishes have been documented in

other countries such as Poland (Andrzej *et al.* 2019); as these foods become popular, also the mushrooms they contain.

As shown by the AIC (Table 3), the model that best explained mycophilic attitudes was that which fused the ethnic group and community, where the vegetation type was the main driving force in the second one. The cultural group model was not the one that best explained the attitude that people presented towards mushrooms, as it occurred in other areas of the country (Ruan-Soto *et al.* 2013), since both the Wixaritari and mestizos presented mycophilic tendencies. Although, while the cultural group to which each person belongs did not influence the degree of mycophilia, it did affect the perception towards some issues as the indicators included here had shown. This coincided with that reported in other ethnic groups throughout the country, where, although traditional knowledge has eroded and has incorporated knowledge from other cultures, Mexican original groups retain perceptions and ethnomycological wisdom since pre-Hispanic times (Garibay-Orijel and Ruan-Soto 2014; Guzmán 2008; Pérez-Moreno *et al.* 2008). For instance, the Wixaritari recognized different species of toxic mushrooms through morphological characteristics because in their cosmivision there is not a polarized conception of good and evil (Neurath 2005; Neurath and Pacheco 2011; Villegas 2016). For them, toxic mushrooms precede the appearance of the edible ones and are necessary for their existence. In contrast, most of the mestizos did not know how to recognize a toxic mushroom.

In other indicators, such as harvest practices and the existence of specialists in this activity, the differences between the cultural groups studied here have nothing to do with mycophobia, but they were due to

the fact that the collection of edible wild mushrooms was an activity that takes place every year among the Wixaritari being wild mushrooms an important resource in their diet; meanwhile, in the mestizo population, the years in which they did not have the means or time to go out to harvest, they usually tend to buy them. Therefore, when we asked about the existence of specialists in the harvest or salespeople, the Wixaritari responded mostly negatively; however, mestizos usually know people who sell mushrooms in the streets or in the market.

In terms of the ecologic traditional knowledge, the Wixaritari were clear that mushrooms grow from the organic matter in decay, such as leaves and trunks, and that is how these organisms are integrated into the life cycle of the forest and other ecosystems. The animals that the Wixaritari mentioned having seen eating mushrooms or related with them, although not necessarily edible ones, range from deer, coyotes, foxes, raccoons, squirrels to turtles. On the other hand, some mestizos mentioned that the cattle could eat mushrooms; nevertheless, most of the mestizos were not aware if any wild animal could eat mushrooms and few possessed knowledge about the role of fungi in the ecosystem. This coincides with Salmón (2000), who proposes that a close relationship with the environment is maintained when it relates with surviving, therefore having greater knowledge about the elements that make up the ecosystem on which the people depend. Examples of this dependence on nature are the original groups who use biota daily, either as food, medicine, in ceremonies or with a symbolic use, among others (Salmón 2000).

All the knowledge around mushrooms was part of the oral tradition heritage that, like other indigenous groups (Toledo 2001), keeps the Wixarika culture alive. This

wisdom ranged from the recognition criteria of edible mushrooms, toxic mushroom conceptions, places and season of collection, to the medicinal use that they attributed to some of them. In contrast, some mestizos mentioned that their parents never taught them how to recognize which mushrooms they could eat, so they feel some sense of distrust towards them. Others mentioned that their children did not want to learn about them, so the kids did not eat mushrooms. In general, mestizos did not use mushrooms to cure specific ailments, but they considered them an extremely nutritious food source that can keep the body healthy and thus avoid diseases. This perception coincided with what was reported by Bautista-González and Moreno-Fuentes (2014).

The probability distribution (Figure 5d) showed that the Wixaritari living near the forests were highly mycophilic, as well as the Wixaritari of Villa Guerrero, who after having migrated from indigenous communities in pine-oak forest to an urban center had adapted and conserved their practices and relationships with mushrooms in the areas of scrubland and a nearby oak forest. However, there were also cases in which mestizo communities (Ciénega de Márquez, Izolta, La Guásima, and Santa Rita), settled in subtropical scrubland (with poorer mushroom diversity, pers. observ.), were higher mycophilic than one mestizo community (Ojo de Agua de Cardos) in oak forest (with richer mushroom diversity, pers. observ.), who had an indifferent attitude to mushrooms. This contrasted with other studies where it was proven that in settlements close to forested areas the availability of the resource favored the establishment of a closer relationship with mushrooms (Burrola-Aguilar *et al.* 2012; Villarreal and Pérez-Moreno 1989).

According to the results of the ordination and classification (Figures 3–4), the two mestizo settlements, Ciénega de Márquez and La Guásima, included in a group with indigenous communities, presented a high degree of mycophilia in the probability distribution (Figure 5d). These communities were the most isolated mestizo communities. The hours of travel by rugged and rustic roads did not make viable the transportation of foreign food for these communities, so they depended mostly on their crops and wild resources. This may have fostered a closer relationship with mushrooms and a great appreciation for them as a food source. This behavior was consistent with that mentioned by Healey and Hunn (1993) on isolated human settlements that had achieved a degree of self-sufficiency as an adaptation to cover their primary needs through the use and exploitation of nearby wild elements. The use of wild resources in remote communities where cultivation is not possible and markets are not available, has been reported in other works such as Kumar (2013) and Misra *et al.* (2008).

In turn, the Wixarika community in Los Valles was included in a group with mestizo communities (Figure 3). The inhabitants settled in Los Valles, with a subtropical scrubland, after being expelled from their original territory located in wooded areas by a privatization process by herders and farmers (Liffman 2011; Torres 2000). Unlike other Wixaritari, in this settlement few people practice temporary migration. These events might have caused a loss of the ethnomycological wisdom. Currently, the new generations do not have any attachment to mushrooms and only the three-elderly people of the community have a broad understanding and knowledge about these organisms. As Mapes *et al.* (2002) established, these variations in the degree of

knowledge might be due to both ecological and historical factors.

The mestizo community Ojo de Agua de Cardos was different from the rest, as shown by the ordination analysis and the probability distribution (Figures 3, 4, 5d). In this site, the people showed no interest in mushrooms, manifesting an apathetic condition as proposed by Ruan-Soto *et al.* (2013). This attitude was maybe due, as in other populations (e.g., Benz *et al.* 2000; Leal *et al.* 2018; Pérez-Moreno *et al.* 2008), to the change in diet and way of life of this people. This community has a greater dependence on agricultural resources, which leads to a disuse of wild resources, and consequently to the loss of traditional knowledge about their utilization. As Saynes-Vásquez *et al.* (2013) mentioned, populations with a higher degree of modernity expressed in several factors, including economic activities, had less traditional knowledge.

In the communities studied, there were more mycophilic men; however, the women presented a greater degree of mycophilia. Despite this, there was no difference in attitude towards mushrooms between women and men. This was similar to that reported by Somnasang and Moreno-Black (2000), who demonstrate that gender did not influence the attitude of Thai people towards wild foods. Other authors, such as Dovie *et al.* (2007) and Sundriyal *et al.* (2004), found that gender did not influence the use, management, and preference among wild plants. Lozada *et al.* (2006) proposed that both women and men had the same knowledge and interaction with wild resources because, although they would play distinct roles, they were in contact with the same ecosystem. In line with the field observations in the municipality of Villa Guerrero, gender roles did not differ in any community, since women and men of both

cultural groups performed the same tasks whether in the countryside or at home. In a similar way to that reported by Mariaca *et al.* (2001), the transmission of knowledge, as well as practical and participatory teaching of children, was carried out by both parents. The differences lied in the place and circumstance of harvesting. Women tended to harvest wild resources in places close to their home throughout the year, while men carried out temporary migrations to their more remote properties, due to the sowing and harvesting cycles, for which they must subsist with wild plants and mushrooms collected there.

Mycophilic attitudes found in the studied communities are reflection of the conservation of traditional ecological knowledge, as was reported in the same municipality by Haro-Luna *et al.* (2019). This knowledge could have implications for the biological conservation because of the appreciation of the wild resources and their strong dependence on the ecosystems.

CONCLUSIONS

In the studied communities, the factor ethnicity alone not explain the degree of mycophilia or mycophobia. However, the traditions and cosmovision of each cultural group affected the attitudes that were demonstrated in some of the evaluated indicators. While for mestizo people, the characteristic that determined whether a mushroom was edible or not was the place where they grew and while they had a vague idea of their function in the ecosystem, the Wixaritari were aware of the ecological role of fungi, and in their conceptions, toxic mushrooms were of significant importance for the maintenance of natural cycles and for the emergence of the edible ones. On the other hand, regardless of the cultural group,

some of the habits and activities of the groups were also influenced by the adaptation to the geographical conditions in an effort to make the most of the resources.

Gender did not determine the mycophilic degree, since the ways and customs of these communities have led men and women to relate in the same manner to their environment. Although the diversity of mushrooms that could be found in areas of subtropical scrub was considerably less than those that grow in temperate forests, people living in semi-arid regions surrounded by this type of vegetation showed clear mycophilic attitudes towards the mushrooms with which they have contact, just as in communities surrounded by forests.

In Wixaritari and mestizo communities, traditional knowledge and the relationship of people with wild natural resources such as mushrooms were affected both by the transformation of lifestyle and economic activities, as well as by historical events that had caused the displacement and adaptation to a new ecological environment. Furthermore, other social phenomena such as the interruption of some traditions, like temporary migration for religious festivities, had also influenced such knowledge and relationships. Only one community did not present mycophilic tendencies due to the fact that mushrooms had an insignificant presence in their lives as a subsistence resource or as part of the knowledge inherited by their parents and grandparents. In this community, knowledge about wild mushrooms stopped being transmitted two generations ago, causing the current apathy towards these organisms.

This work demonstrated that, in the study area, traditional knowledge about mushrooms changed over time due to historical-social factors and this in term could affect the degree of mycophilia of a

population. The conceptions that a person had towards mushrooms could be influenced by the cultural group to which they belong as well as the type of vegetation with which they had the most contact. Nevertheless, people with high degree of mycophilia, whether mestizo or indigenous, could be found in semi-arid territories in which the appreciation and taste towards mushrooms was high even though there were few species present. In the same way, attitudes of apathy towards mushrooms could be found in places where this resource was widely available, due to the displacement of wild resources by other commodities.

Understanding the different aspects that influence how different cultural groups perceive fungi, we can have a clearer idea of how these people are related to fungi and get closer to knowing how it has been over time. This knowledge is of great help when we seek to build strategies that allow better use and conservation of resources.

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