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Traditional knowledge surviving the new millennium: women's use of wild edible plant species in a Protected Natural Area.

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Abstract

Background

Traditional knowledge on wild edible plants is at risk due to modernization and cultural erosion. Documenting this knowledge, especially in protected areas that overlap with biocultural hotspots, is important for biodiversity conservation, food security, and cultural heritage preservation. Our study aimed to document Tzotzil Mayan women's traditional use of wild edible plants within the Selva El Ocote Biosphere Reserve in Chiapas, Mexico. By doing so, we intended to contribute to biodiversity conservation efforts, enhance food security, and safeguard cultural heritage.

Methods

Semistructured interviews were conducted with 25 female heads of household in Emiliano Zapata, a community located in the Reserve's buffer zone. Information was gathered on the wild edible plant species used, plant parts consumed, preparation methods, and frequency of use. Plant samples were collected for identification. The data were analyzed to assess differences in species richness and diversity between the dry and rainy seasons and the influence of sociocultural factors such as education level and age on traditional knowledge.

Results

A total of 30 native plant species from 22 families were documented as wild edible plants, with leaves (40%) and fruits (33%) being the most commonly consumed parts. Species richness was greater in the dry season (22 species), while diversity was greater during the rainy season. Solanum americanum (nightshade) had the highest frequency of mention. Women with an elementary education reported knowing and using significantly more edible species than noneducated women. Older women exhibited a marginally greater frequency of use than younger women.

Conclusions

Our findings highlight the importance of traditional knowledge in identifying wild edible plant resources within protected areas. However, this knowledge faces threats from modernization and a decline in intergenerational transfer, as evidenced by the lower usage among younger women. Establishing policies that protect biodiversity hotspots, restore degraded areas, and recognize indigenous knowledge systems is crucial for the sustainable use of plant resources and maintaining biocultural diversity.

Introduction

Historically, all human societies have held a close connection with nature. Within this long history, a significant amount of knowledge on the uses of wildlife has been accumulated and taught from generation to generation, particularly in indigenous communities [1]. Today, millions of people still collect plant resources to fulfill various daily requirements for food, medicine, housing, fuel, rituals, and other purposes. Most people in less developed countries derive a substantial share of their subsistence and income from wild plant products [2, 3]. Numerous contributions in ecology, evolution, and other fields highlight the value of traditional knowledge for problem solving [4–7]. Many publications have focused on the complex and changing relationships between humans and plants, from prehistoric times to the present [1, 8]. Biodiversity knowledge is thus crucial for meeting basic human needs. Despite the latter, traditional knowledge is in danger because of the current dominant economic paradigm, which has favored the overexploitation of forests, watersheds, and biodiversity [9–12].

The intergenerational transmission of knowledge is an essential function of culture that has a significant impact on human behavior and health [13]. This cultural process can serve as a source of resilience and can favor group survival during periods of hardship (Quave and Pieroni, 2015). Vandebroek et al. [15] examine the growing disconnect between local communities and their traditional knowledge systems, particularly in developing countries. For example, they provide environmental knowledge related to agricultural and farming methods, where biodiversity is utilized for purposes such as food, medicine, fuel, shelter, and clothing. Environmental knowledge is also important for understanding basic ecosystem processes and relationships, as well as climate patterns [16]. Today, various factors contribute to the erosion of traditional knowledge systems [17, 18], predominantly a market-based societal model, and the historical marginalization of indigenous peoples. This loss of knowledge is a significant threat to biodiversity conservation, human health, and sustainable development [15].

Wild edible plants have been an important source of food for humans throughout history and continue to be an essential component of the diets of many communities around the world [19–22]. Several studies have documented wild edible plants used by local populations in America [20, 23–26], Europe [14, 27–31], Asia [22, 32–35], and Africa [36–40]. The ongoing loss of traditional knowledge can be summarized as follows: 1) Newer generations have abandoned their homes in rural areas in search of better incomes, therefore shifting their occupation from subsistence agriculture to paid labor. This has resulted in a lost interest in traditional diets; 2) the consumption of local and native foods has been declining due to the influence of imported consumption patterns, such as the proliferation of industrialized and ultra-processed foods [13]; 3) as there is not enough demand in cities, traditional agricultural production systems have also been declining, with regional repercussions on the conservation of native species and all their associated benefits. Furthermore, Cruz et al. [41] found that native foods in rural environments are associated with being poor, and in contrast, consuming industrialized foods is often associated with status and prestige [42, 43]. Rural lifestyle changes have caused severe reductions in the management and care of wild plants consumed by human societies for various purposes. When wild food plants are no longer collected, a significant part of edible plant diversity is lost; consequently, future generations will lose access to essential knowledge about the local environment and edible wild plants [44]. This should not be approached lightly, considering the growing evidence that modern diets are related to obesity and other diet-related diseases, a growing problem that has become a significant burden on world economies [45, 46].

Knowledge derived from human interactions with plants has become highly relevant to many global challenges, such as food security, climate change, conservation biology, and human health [15], as was recognized in the 1992 Convention on Biological Diversity [47]. Loreau and Hector [48] pinpointed the consequences of biodiversity loss as a matter of public interest and debate. Because of the high extinction rates, inventories carried out in the most timely manner possible [48, 49] must provide rapid and reliable information for identifying and recording the species present in a particular region [50]. Local knowledge comprises components that are relevant to conservation efforts, as evidence of quantifying ecosystem services is emerging. This also applies to the ways in which indigenous and agricultural societies perceive, use, and manage biodiversity [51]. Some examples that show how these interactions occur include traditionally managed coffee agroecosystems [52], cocoa [53], and vanilla plantations [54] and the existence of sacred groves [55], societal taboos [56], or local embargoes [57].

Boege [11] and Gorenflo et al. [58] explored the relationship between cultural and biological diversity in areas of high biodiversity, such as biodiversity hotspots and wilderness areas. Their studies revealed that regions with high levels of biological diversity are often found in conjunction with areas of significant cultural diversity. The conservation of natural biotas can be facilitated through recognition, involvement, appreciation, and collaboration with indigenous peoples and *campesinos*, who are the owners and stewards of traditional knowledge. This approach is emphasized by global organizations such as the IPBES and IPCC, as well as by authors such as Saslis-Lagoudakis and Clarke [16]. Mexico is home to one of the world's most abundant biocultural diversities, as highlighted by Toledo and Barrera Bassols [45] and Boege [11]. Complex networks of interactions between social and natural elements and systems create a mutually influential relationship between culture and nature [59]. The latter is exemplified in Mexican protected natural areas (PNAs hereafter), which often overlap with biocultural diversity hotspots. Despite the importance of PNAs in maintaining biocultural diversity, studies on the plants used as food in these regions are scarce [20, 24, 60].

Documenting local knowledge and the use of edible collected plants is highly relevant for more effective and collaborative management of PNAs [17, 20]. According to Gadgil et al. [61], valuing traditional knowledge of indigenous societies is key for ecosystem conservation, both locally and globally. Various studies and authors have recently provided evidence that incorporating indigenous knowledge into conservation practices results in more successful conservation outcomes and greater local community involvement and engagement [62, 63].

Within this scenario, this study aimed to document the use of edible plants in the Mayan community in Ocozocoautla, Chiapas, Mexico. We analyzed differences in the use of wild edible plants between the dry and rainy seasons. Because many plants grow during the wet season, we expected greater species richness and variety. Additionally, we assessed whether women's sociocultural context is related to their knowledge and use of wild plants as food. We also expected a differential response related to age, as older generations are often the primary source of knowledge and younger generations rely on their elders for guidance and instruction. Furthermore, we analyzed the impact of formal education on the traditional knowledge of Mayan women. We understand that sociocultural conditions have various underlying causes. However, knowledge about edible wild plants can improve people's diet and aid in the conservation of wild species within the PNA Selva El Ocote Biosphere Reserve in Chiapas.

Study area

The study was performed in Emiliano Zapata, a small community from the municipality of Ocozocoautla, Chiapas, Mexico, located in the PNA buffer zone of the Selva El Ocote Biosphere Reserve. Geographically, it is located at 16° 57' 40" N and 93° 30' 11" W (Fig. 1). Common land covers an area of 530 hectares and has an average elevation of 783 m.a.s.l. The weather is hot and humid, with an average monthly temperature exceeding 18°C [64]. Tropical evergreen forests [65] are predominant: “Moju blanco” (*Brosimum alicastrum Sw*), “Sapotillo” (*Manilkara zapota* (L.) P. Royen) and “Cedro” (*Cedrela odorata* L) are representative tree species in the area. In the understory, epiphytes and climbers, such as the highlighted palm species *Chamaedorea*, Tzitzún (*Astrocaryum mexicanum* Liebm. ex Mart), Mullein (*Dioscorea composita Hemsl*), Cocolmeca vine (*Dioscorea bartletti* C.V. Morton), and Cycad “Tapacarpon or Amenduai” (*Ceratozamia robusta* Miq.) [64].

Emiliano Zapata is a small village inhabited mainly by the Tsotsil ethnolinguistic group. The first settlers emigrated in 1985 from the Chiapas highlands [64]. The locality has two levels of educational instruction: preschool education (for under three years old), with a single teacher who teaches the three grades, and an elementary school (for six to twelve years old) that offers basic instruction from first to sixth grade. There is no secondary or high school education [64]. As a small community, we carried out a house-to-house census with the previous authorization of the local authority. This study revealed that the total population is 172 inhabitants, 56% of whom are men and 44% of whom are women.

Materials and Methods

We conducted twenty-five semistructured interviews with local women who were also heads of household. The surveys recorded the name, age, and educational level of the participants in elementary school. We identified the wild plant species used for food, the weekly consumption frequency, the part of the plant used (leaves, fruit, seed, root, or flowers), and whether the plants were consumed cooked or raw [29].

Fieldwork was conducted during two distinct seasons: the dry season (November to April) and the rainy season (May to October). The relative importance of each species was obtained directly from the degree of consensus among informants through the Fidelity Level (FL) proposed by Friedman [66] (1):

1) $FL = (IP/IT) \times 100$

where IP is the number of respondents who mentioned one species (frequency of mention) and IT is the total number of respondents.

The surveys allowed us to collect information about wild edible plants commonly found along fifteen trails located throughout the reserve that are regularly used by local women. To identify the uncultivated edible plants growing on both sides of each path, we followed the method described by Lot and Chiang [67]. Samples were collected and identified by comparison with the scientific collection of the Eizi Matuda (HEM) herbarium at the Institute of Biological Sciences from the University of Science and Arts of Chiapas (UNICACH). We also created a database that included information about the collected plant families, genera, and species. To ensure accuracy, we used the nomenclature of APG IV [68] for all vascular plants listed in the angiosperm category and verified all scientific names using http://www.worldfloraonline.org/.

Data analysis

We utilized beta diversity profiles to assess the richness and diversity of wild edible plant species across both the rainy and dry seasons [69]. To quantify diversity, Di Battista et al. [69] introduced three functional measures (the first and second derivatives, the radius of curvature, and the length of the curvature), which are combined to produce a scalar measure known as the area under the curve (hereafter referred to as diversity). To calculate the metrics for both species richness (S) and diversity, we employed the BioFTF (Biodiversity Assessment Using Functional Tools package for R) in R version 4.1.3 (2022) and RStudio version 4.0.3 [70] (view appendix 1).

We used a generalized linear model (GLM) to study the data with a gamma distribution error. Our goal was to determine whether there was a connection between women's use of wild edible plants and their elementary education level. We considered factors such as their knowledge of the plants, frequency of use, and utilization patterns. Women's education levels were grouped into three categories: noneducated, up to third grade, and over the third grade of elementary school. Additionally, we divided women into two age groups, young (aged 15–33 years) and older (aged 34–67 years), to explore whether age affects wild edible plant utilization. All the statistical analyses were conducted using a significance level of $p < 0.05$ and the software R (R Development Core Team, 2022; see Appendix 1) with the following libraries: *readr* [71], *BioFTF* [71], *effects* [72], *AER* [73], and *multcomp* [74].

Results

We found that in the Emiliano Zapata locality within the Selva El Ocote Biosphere, Tzotzil women used 30 wild edible plant species during both the dry and rainy seasons (see Table 1). These plants belonged to 22 families and 27 genera, 90% (N = 30) of which were native. Regarding usage patterns, 40% of the identified wild edible species were predominantly utilized for their leaves, 33% for their fruits, 10% for their seeds, 10% for their roots, and 7% for their flowers. In terms of consumption, these plants were primarily cooked (70%) rather than consumed raw (30%).

Table 1
Species list of wild edible plants known by women in Emiliano Zapata locality. Frequency of mentions and Friedman index are reported for both dry and rainy seasons.

				Dry		Rainy	
Family	Scientific name	Spanish name	Tzotzil name	Frequency	Friedman Index (FI)	Frequency	Friedman Index (FI)
Amaranthaceae	*Amaranthus hybridus* L.	Bledo	Ts´ul itaj	3	12	1	4
Anonaceae	*Annona macroprophyllata Donn. Sm*	Papausa	Papausa	1	4	1	4
Annonaceae	*Annona muricata* L.	Guanabana	Kuanabana	1	4	0	0
Annonaceae	*Annona purpurea Moc. & Sessé ex Dunal*	Chincuya	Chinkuya	1	4	4	16
Araceae	*Colocasia esculenta* (L.) Schott	Malanga	Malanka	1	4	1	4
Arecaceae	*Astrocaryum mexicanum* Liebm. ex Mart	Chapaya	Chapaya	14	56	0	0
Arecaceae	*Chamaedorea tepejilote* Liebm.	Pacaya	Papaya	9	36	0	0
Bignoniaceae	*Parmentiera aculeata* (Kunth) Seem	Cuajilote	Vajilote	1	4	2	8
Bixaceae	*Bixa orellana* L.	Achiote	Jo´ox	1	4	0	0
Caricaceae	*Carica papaya* L.	Papaya	Lot som	1	4	2	8
Amaranthaceae	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	Epazote	Koko´on	2	8	5	20
Asteraceae	*Sinclairia glabra* Rydb.	Gamuza	Gamuza	1	4	0	0
Asteraceae	*Sonchus oleraceus* L.	Chicoria	Chikoria	1	4	0	0
Convolvulaceae	*Ipomoea batatas* (L) Lam	Camote	Tsajal Isak ´	0	0	3	12
Brassicaceae	*Brassica oleracea* L.	Colinabo	Napux	20	80	21	84
Euphorbiaceae	*Cnidoscolus aconitifolius* (Mill.) I.M. Johnst.	Chaya	Chay itaj	1	4	0	0
Euphorbiaceae	*Manihot esculenta* Crantz	Yuca	Ts´inte´	0	0	9	36
Lamiaceae	*Mentha piperita* L.	Hierba buena	Yaravena	1	4	2	8

				Dry		Rainy	
Lauraceae	*Persea americana* Mill.	Aguacate	On	0	0	4	16
Fabaceae	*Crotalaria longirostrata* Hook. & Arn.	Chipilin	Ch´aben	9	36	17	68
Fabaceae	*Leucaena esculenta* (DC.) Benth.	Guash	Paka´	0	0	1	4
Malpighiaceae	*Brysonima verbascifolia (L.) DC.*	Nanchi	Lantsin	4	16	11	44
Myrtaceae	*Psidium guajava* L.	Guayaba	Potoj	0	0	7	28
Moraceae	*Brosimum alicastrum* Sw.	Mojú	Mojú	0	0	1	4
Passifloraceae	*Passiflora edulis* Sims	Granadilla	Karanato	0	0	3	12
Piperaceae	*Piper auritum* Kunth	Hierba santa	Mumun	1	4	8	32
Portulacaceae	*Portulaca oleracea* L.	Verdolaga	Vertolaka	3	12	2	8
Solanaceae	*Physalis minima* L.	Tomatillo	Chichol	2	8	0	0
Solanaceae	*Solanum americanum* Mill.	Hierba mora	Muil itaj	24	96	25	100
Solanaceae	*Witheringia meiantha* (Donn. Sm.) Hunz	Cuña	Kunya	2	8	2	8

Specifically, *Solanum americanum* Mill (Hierba mora, in Spanish, or Muil itaj, in Tzotzil) had the highest Friedman index value in both seasons (FL = 96% in the dry season and FL = 100% in the rainy season). The FLs of *Brassica oleracea* L. (Colinabo or Napux) were 84% and 84% in the dry and rainy seasons, respectively. *Crotalaria longirostrata* Hook. & Arn. (Chipilín or Ch’aben) had an FL of 68% in the rainy season, and *Astrocaryum mexicanum* Liebm. ex Mart (Chapaya) had an FL of 56% in the dry season (Table 1). Species richness is greater in the rainy season, resulting in greater utilization of wild edible plants during this season (Table 2).

Table 2
Diversity and richness indices of wild edible plant species in both seasons (rainy and dry).

Seasons	Richness	Shannon	Simpson	Diversity (surface area)
Rainy	21	2.809	0.898	9.489
Dry	22	2.642	0.871	9.376

We found variations in the knowledge and utilization of edible species among the surveyed women groups. Women with an elementary education reported a greater number of known species than women without a formal education (Deviance = 4.99, df = 24, p = 0.05; Fig. 2a). Similarly, the number of species used was 1.86 times greater among elementary school-aged women (1.83 versus 099 on average) than among women without education (Deviance = 7.01, df = 24, p = 0.02;

Fig. 2b). On the other hand, the use of wild edible plant species showed a marginally significant difference between the two age categories of women. The frequency of use was greater for older women (deviance = 1.75, df = 24, $p = 0.08$; Fig. 2c).

Discussion

Contrary to our prediction, species richness was greater during the dry season, but diversity was greater during the rainy season (Table 2). We reported several edible species similar to what has been reported in other studies.

Compared with other studies, we found a similar number of edible species as reported in other publications. For example, in Hidalgo, Mexico, Figueredo-Urbina et al. [75] listed 30 species whose flowers are consumed or used as flavorings and dyes in various traditional culinary preparations. Other more extensive studies found a greater number of used species. For example, Ashagre et al. [19] recorded 46 wild edible plant species across five study sites in the Burji District, Segan Area Zone of Ethiopia. Meanwhile, Pawera [76] documented 85 species through interviews with 200 women and focus group discussions with 68 participants in West Sumatra, Indonesia. In another study, Mokganya et al. [3] reported 92 wild edible fruit plant species belonging to 20 different plant families from semistructured interviews with 160 informants in Limpopo Province, South Africa.

Our study revealed a high number of wild edible plant species within a protected area. Blanckaert et al. [24] reported 17 species of edible plants, specifically weeds, in Oaxaca inhabited by the Mestizo and Mazatec communities. Vazquez-García et al. [23] studied the use of wild plant species in the diet of native inhabitants of Sierra de Santa Martha, Veracruz, within the Los Tuxtlas Biosphere Reserve; although Los Tuxtla has a similar vegetation type, only three species matched the species found in our study. The differences in the number of species among these studies may be attributed to the vegetation type. The Tehuacán-Cuicatlán Reserve is in a semiarid region, unlike the El Ocote Biosphere Reserve, which is characterized by tropical rainforests [65]. However, Los Tuxtlas Reserve is also located in the Mexican tropical rainforest area [77].

Nightshade (*Solanum americanum*) was the most consumed species throughout both the rainy and dry seasons. This could be attributed to the fact that this plant is native and perennial [78], making it readily available for consumption year-round, and it is also commonly found in open and disturbed areas such as roadsides, pastures, and abandoned fields [79].

The prevalence of cooked preparations of edible plants (70%) suggests that indigenous people have taught locals that potentially harmful plant components can be eliminated by cooking.

In this study, the consumption of leaves (40%) and fruits (30%) was found to be greater than that of other parts of the plants. Leaves are preferred for their soft texture and easy availability. According to several authors, fruit consumption is attributed to the pleasant taste and nutritional benefits of fruits [29–31]. This is important because studies suggest that wild plants can provide several health benefits and enrich the diet of rural communities [24]. Additionally, according to Pieroni et al. [29], wild edible plants not only contain essential nutrients but are also rich in phytochemicals, vitamins, and minerals that have health benefits, including antioxidant properties that can help prevent age-related diseases [80, 81].

Wild edible plants have been used as important food resources by indigenous people in many places [43, 63, 82, 83]. Despite their potential to provide sustenance, the nutritional content of these plants has not been sufficiently explored. In some Latin American and African countries, these plants serve as food staples or complementary sources, and they are also considered potential supplements of B vitamins worldwide [14, 43, 63].

Intergenerational dialogs and knowledge sharing on the use of wild plants are essential for maintaining traditional knowledge and practices related to the sustainable use of natural resources [84, 85]. In particular, the traditional ecological knowledge of women involves practices and beliefs that evolve through adaptive processes and are maintained through cultural transmission [6]. Studies in Patagonia, Argentina, have provided evidence of a substantial reduction in knowledge among younger and suburban populations regarding the use and management of wild plants [21, 26]. Pawera et al. [22]

also reported a decrease in the use of wild edible plants by younger generations in Indonesia. We found a similar pattern in Emiliano Zapata, a relatively isolated community where edible plants were less frequently utilized and mentioned by younger women. Our results thus suggest that the intergenerational transfer of traditional knowledge regarding wild edible plants may be at risk in Emiliano Zapata, given that younger women exhibited a decrease in their knowledge.

Several studies have shown that a higher education level is associated with greater use and knowledge of wild edible plants [3, 19, 21]. Based on research by Mokganya et al. [3] and our results, women with education beyond the third grade are more likely to use wild edible plants. Education level, age, and gender were found to affect knowledge of wild edible plants by Ashagre et al. [19]. Ladio and Lozada [21] observed that higher education levels among women in a Mapuche community in Patagonia led to better knowledge of wild edible plants. Wild edible plants have been used for centuries by indigenous communities as sources of food and medicine. In recent years, there has been growing interest in the health benefits of these plants, which are often rich in vitamins, minerals, and antioxidants [43, 86].

In our study area, Caballero-Roque [80] observed high concentrations of proteins and lipids in the wild edible plants. This finding is consistent with Nabhan and Felger (1985), who reported high levels of proteins and lipids in various plants used for food by populations living in arid regions of Mexico. Additionally, Booth et al. [87] reported three times greater protein content in green leaves used for consumption by the Kekchi population in Guatemala. Sotelo et al. [43] reported a maximum protein content of 275 g/kg-1 in eight species of edible wildflowers from Puebla, Hidalgo, and Mexico City in Mexico.

Traditional knowledge of wild edible plants can serve as a valuable resource for nutrition, conservation, and medicine, and recognizing its importance can lead to the development of more sustainable practices that support both human communities and the preservation of biodiversity. However, despite their importance, traditional knowledge of wild edible plants is threatened by modernization and the loss of traditional culture.

Conclusions

We documented that Tzotzil women consumed 30 wild edible plant species during dry and rainy seasons, and leaves and fruits were preferred for consumption. Additionally, they chose to cook rather than consume raw food. Contrary to our initial hypothesis, the results showed that the species richness of wild edible plants was greater during the dry season. In contrast, species diversity was greater in the rainy season, as we expected. The Nightshade (*Solanum nigrum*) had the highest Friedman index value in both seasons. This species is abundant and widely utilized throughout the year in this locality due to its hardiness and resilience, which allow it to withstand adverse environmental conditions, including those caused by climate and anthropogenic activities. Women with an elementary education reported and used more known species than women without a formal education. To promote the sustainable use of plant resources for food, it is crucial to establish policies that not only protect biodiversity hotspots but also restore degraded areas and acknowledge the importance of traditional knowledge regarding the uses of plants for various purposes in protected natural areas. The values and traditions of local communities should be considered because of their ecological and sociocultural diversity.

Abbreviations

FL Fidelity Level

GLM Generalized linear model

HEM Herbario Eizi Matuda (Herbarium Eizi Matuda)

IPBES Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IPCC Intergovernmental Panel on Climate Change

PNA Protected natural areas

UNICACH Universidad de Ciencias y Artes de Chiapas

Declarations

Ethics approval and consent to participate

The authors followed the guidelines of the International Society of Ethnobiology.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

ACR, SL, MPF and CTC designed the study and analyzed results, ESR, MLT contributed to the conceptualization and data analysis of the results. ACR gathered the research data. All authors participated in manuscript writing and revision.

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Figures

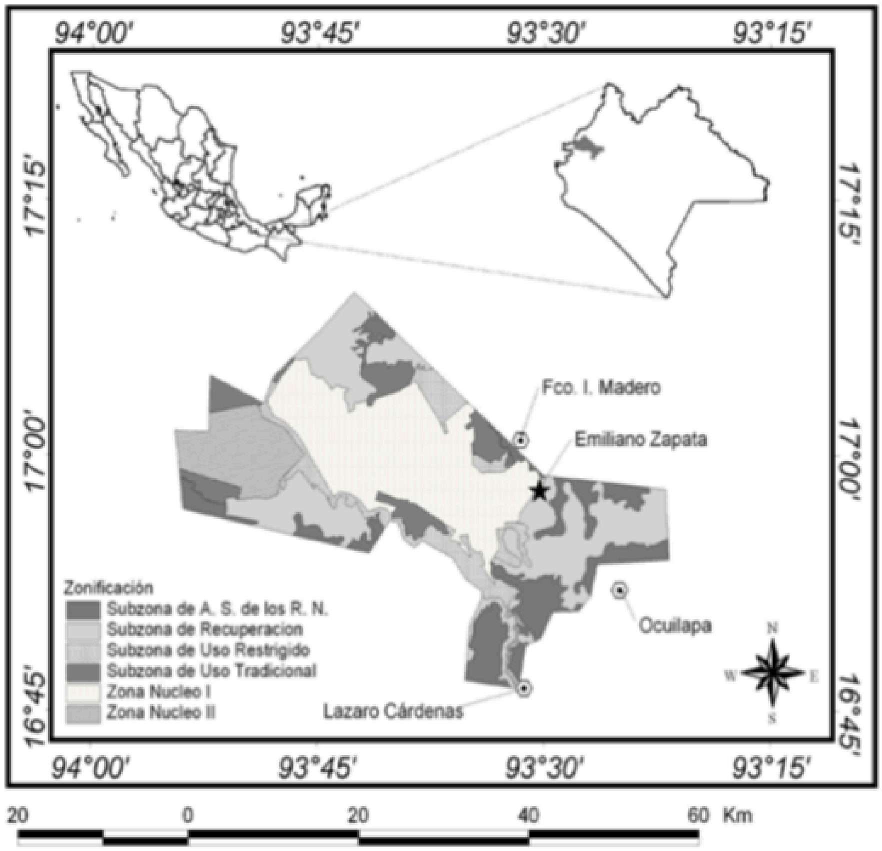

Figure 1

Map of the study area: Emiliano Zapata village, inside the Biosphere Reserve “Selva El Ocote”, Chiapas, Mexico

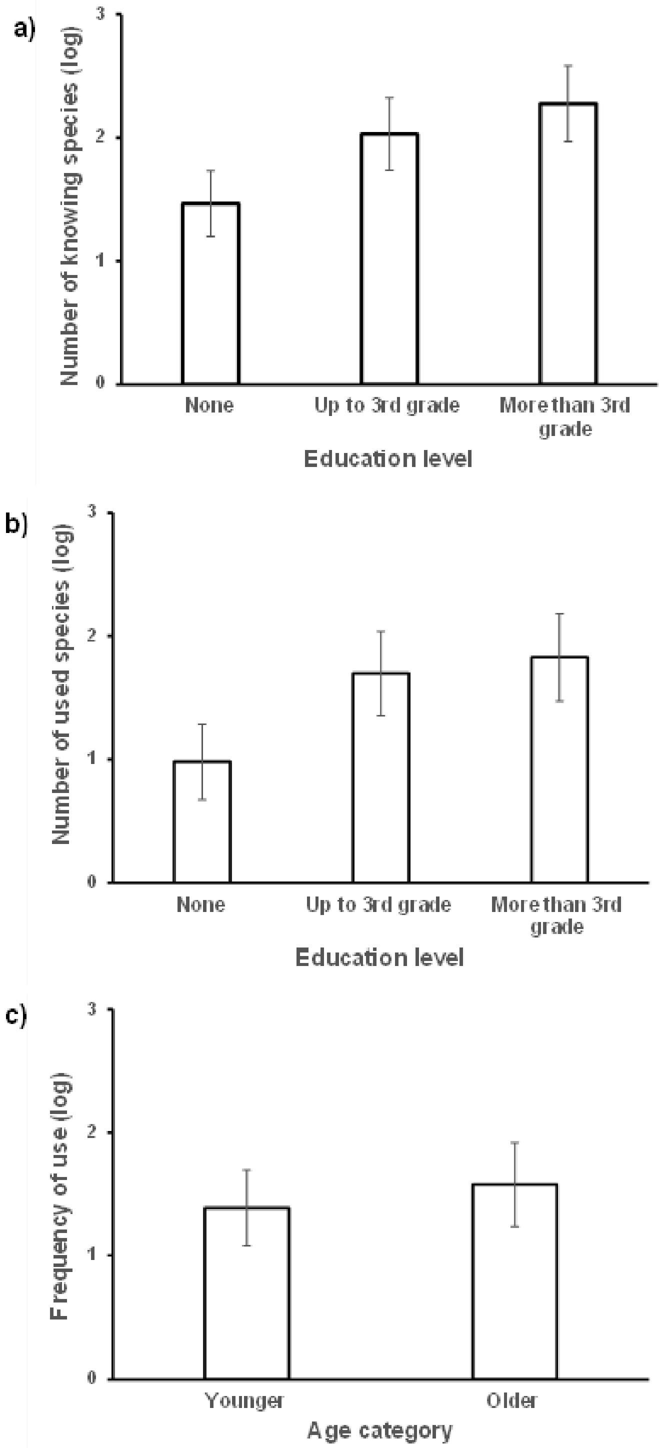

Figure 2

The plot of GLM analysis between education level and knowing (a), education level and using (b), and age category and frequency of use (c).