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Traditional ecological knowledge on flora and fauna of el Zapotal Natural Protected Area, México[1]

Conocimientos ecológicos tradicionales sobre flora y fauna del Área Natural Protegida el Zapotal, México

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Abstract

El Zapotal is a Natural-Protected Area (NPA) that preserves the last patches of the sub-evergreen forest of the central valleys of Chiapas, México; there are species of native flora and fauna. The objective was to identify the perception, Traditional Ecological Knowledge (TEK), and the uses that the inhabitants of the area surrounding this NPA make of the local/native flora and fauna. The research uses two tools of the ethnographic method: participant observation and semi-structured interview; 17 key actors participated using the *snowball* technique. The interviewees have a positive perception of the NPA; they demonstrated that they know different species of flora and fauna (distribution, feeding, behavior), although this knowledge is not deep due to the control and isolation of the NPA. Finally, they use some species of flora and fauna for food, medicine, or firewood.

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Keywords: biodiversity, ecosystem, perception, natural resources, interview.

Resumen

El Zapotal es un Área Natural Protegida (ANP) que conserva los últimos fragmentos de selva mediana subperennifolia del valle central del estado de Chiapas, México; allí existen especies de flora y fauna nativas. El objetivo de la investigación fue identificar la percepción, los Conocimientos Ecológicos Tradicionales (CET) y los usos que los pobladores del área aledaña a esta ANP aplican sobre la flora y fauna local/nativa. Para ello se utilizaron dos herramientas del método etnográfico: la observación participante y la entrevista semiestructurada; con la técnica de *bola de nieve* se contó con la participación de 17 actores clave. Los entrevistados poseen una percepción positiva de la ANP y demostraron poseer CET sobre distintas especies de flora y fauna (distribución, alimentación, comportamiento), aunque dichos conocimientos no son profundos, debido al control y aislamiento del ANP. Finalmente, los locales utilizan algunas especies de flora y fauna como alimento, medicina o leña.

Palabras clave: biodiversidad, ecosistema, percepción, recursos naturales, entrevista.

Introduction

Ethnoecology inquires into the complexity of culture and nature, attempting to understand and characterize the relationship between human beings and how they develop to satisfy their needs using nature (di Pasquo *et al*., 2023). Currently, this discipline focuses on the multifaceted study of TEK (Toledo & Barrera, 2020; Díaz-Gómez *et al*., 2023), which people possess over the local flora and fauna, in the structural sense of the analysis of their genesis, their sociological and ecological functions, their history, and the expressions of these assemblages in the dominant community where they place (Sepúlveda Varón *et al*., 2022). Unlike much-standardized knowledge developed by the exact sciences, some TEK are forged in situ through trial and error by all those who use the territory's natural resources and abiotic elements, adjusting management models adapted to the characteristics of local ecosystems (Roger, 2020).

It should be understood that the alteration and destruction of natural ecosystems generally translate into backwardness and social inequality that affect the behavior of the people belonging to that reality, who look to the natural environment for the fundamental elements to meet their needs (Reyes *et al*., 2021). Research on the people-nature relationship should consider visual or physical characteristics and delve into the intimate aspects of experiences in more empathetic and less classificatory features (Castillo-Retamal & Cordero-Tapia, 2020). In most cases, communities are isolated or separated from decision-making related to environmental public policies by excluding their voices (Sosa-Martínez *et al*., 2020). In many cases, the knowledge and perceptions of our indigenous peoples and rural communities represent the response to a particular mode of moral scarcity and environmental education perceived in urban centers since, somehow, peasant life is attached to the use of the natural environment and respect for natural resources, which poses a tremendous sentimental value to meet the needs of rural regions (Sánchez, 2019). Thus, understanding and studying the environmental perceptions of the subjects that make up a socio-environmental context allows obtaining congruent information to establish judgments that revolve around their human and spiritual sensations regarding the environment with which they coexist (Ruiz & Valcuende, 2020). TEK, which is structured as a cumulative system represented by experience, careful observation, and experimentation applied from person to person (Garth & Ruiz, 2018), plays a crucial role in the solution of environmental problems since, from this knowledge, sustainability and balance with the environment can be achieved (Leyva, 2019).

The people who live directly with the local flora and fauna species must be included in the management and conservation plans for any ecosystem; therefore, it is primal to conduct studies not only on the impact that local anthropogenic activity has on natural resources (uses, productive activities) but also to conduct ethnoecological studies that allow us to know the perception and TEK that the inhabitants maintain about these resources (Ortega & Casas, 2022).

El Zapotal is a NPA in Tuxtla Gutiérrez, Chiapas, México. It is considered an area of main relevance because, on the one hand, it shelters one of the last fragments of the medium sub-evergreen forest of the central valley of the state of Chiapas, and on the other, it

harbors a significant diversity of vertebrates (Rodríguez-López *et al.,* 2019); in fact, the National Commission for the Use and Knowledge of Biodiversity (CONABIO) lists el Zapotal as a conservation area for birds (native and migratory); in addition, within the reserve there are several springs, such as the one called la Cueva, which supplies water to the Miguel Álvarez del Toro Zoo (ZOOMAT) and the Rivera Cerro Hueco neighborhood (Secretaría de Medio Ambiente e Historia Natural [SEMAHN], 2013). Finally, within el Zapotal is located the ZOOMAT, whose nature embodies a unique zoo in the world, with the exclusive presence of native species of flora and fauna (SEMAHN, 2020). This study formulated several hypotheses about the perception, uses, and TEK of the flora and fauna of el Zapotal: (a) the inhabitants surrounding el Zapotal have a positive perception of the NPA because they obtain natural resources from it; (b) the inhabitants next to the NPA have TEK about plant and animal species of el Zapotal, and (c) the inhabitants adjacent to el Zapotal use diverse species of flora and fauna for multiple purposes. This information explores local knowledge and is essential for adequate and sustainable management (conservation) protocols for the NPA and its species. The objective was to identify the perception, the TEK, and the uses that the inhabitants of the area surrounding this NPA make of the local/native flora and fauna.

Methodology

Study area

The study area is located in el Zapotal, a state NPA, south of the capital city Tuxtla Gutiérrez, Chiapas, México, between coordinates 16°43'42.34"N, 93°6'2.12"W, and 16°43'22.53"N, 93°5'37.15"W, at an altitude of 600 to 850 masl (SEMAHN, 2013). El Zapotal is bordered to the south by the Francisco I. Madero neighborhood (8032 inhabitants) and to the west by the Rivera Cerro Hueco neighborhood (2090 inhabited private homes). It was decreed as an NPA on August 27, 1980, and reached an area of 192.57 hectares (SEMAHN, 2020).

Type of study

The study was conducted using a mixed approach. It used two tools of the ethnographic method: participant observation and semi-structured interviews (Zenteno *et al.,* 2022). According to Cotán (2020), the ethnographic method aims to describe, deepen, and characterize the people of a specific site or place. It pretends to identify and understand their habitual behavior, explaining their beliefs and the meanings of all their actions.

Selection of collaborators

Between February 8 and March 28, 2021, prospective visits were made to the SEMAHN-ZOOMAT facilities to present the project and recognize the NPA. The officials pointed us to our first collaborator, a park ranger who knew the inhabitants of the neighborhoods adjacent to el Zapotal. The snowball technique was used to contact the rest of the collaborators who live in the nearby areas, both in Francisco I. Madero and Rivera Cerro Hueco. This method identifies hidden and spontaneous populations of new characters through initial subjects (Kumar, 2022). Seventeen collaborators participated.

Semi-structured interviews

The semi-structured interview collects personal and detailed information, using a sequence and previous questions to determine a focus, and it is also characterized by the openness or freedom to change such sequence and the form of the questions, depending on the interviewee's situation (Lopezosa, 2020). In this case, the questions focused on the perception, uses, and TEK that each collaborator showed on the flora and fauna species of the NPA.

The interviews took place between June 1 and July 30, 2021, as follows: face-to-face with each collaborator, a greeting was extended, then a conversation was held to explain the reason for the interview, the objectives and topic of the research, and finally to obtain permission to conduct the interviews, in compliance with the Code of Ethics of the Mexican Association of Ethnobiology (García *et al*., 2020). Each semi-structured interview was completed in a conversation that lasted up to 45 minutes, approximately (depending on the interviewee).

At the end of each one, gratitude was expressed for the time given, and using the snowball technique (asking for collaborators who could contribute to the interviews), future interviewees were registered to track them down and continue with the research. The interviews were recorded with a Panasonic RR-XS350 model digital recorder and in a field log, with the prior verbal consent of the interviewees. Data on each interviewee, such as sex, occupation, age, name, and period of residence, were recorded and entered into an Excel database (Table 1).

Subsequently, the interviews were transcribed into a word processor to obtain future categories for analysis (Díaz-Gómez *et al*., 2023). It was necessary to show in a data table the tenure of our interviewees to suggest that the variety of informants concerning their occupation does not influence their perception. However, it does with their knowledge, as with our informants who work or have worked in el Zapotal, who demonstrated a more systematized knowledge.

Table 1
Data on essential actors

Essential actor	Sex	Age	Period of residence	Occupation
1	Female	21	21	Merchant
2	Female	30-35	20	Merchant
3	Female	59	24	Housewife
4	Male	ND	11	Retired (ZOOMAT)
5	Female	46	46	Housewife
6	Female	30	30	Merchant
7	Female	29	29	Student
8	Male	50	15	Construction worker
9	Male	78	40	Farmer
10	Female	62	22	Merchant
11	Male	51	50	ND
12	Female	56	25	Housewife
13	Female	59	12	Housewife
14	Female	30	15	Housewife
15	Male	64	42	Retired
16	Male	69	69	Plumber (ZOOMAT)
17	Male	59	59	Maintenance (ZOOMAT)

Note. ND: No Data. Source: own elaboration.

Participant observation

It implies that the researcher is integrated into the study site, becoming directly concerned with the group under observation, either entirely or during a specific period (Sánchez *et al*., 2021). The data obtained may be more accurate due to the closeness and trust generated among the participants.

Over a year, periodic visits were made to the NPA, the ZOOMAT facilities, the perimeter limits of el Zapotal, and the immediate neighborhoods. Residents, park rangers, or NPA staff always accompanied these visits (Figure 1 and Figure 2). During these tours, we witnessed the daily life inside el Zapotal and perimeter areas.

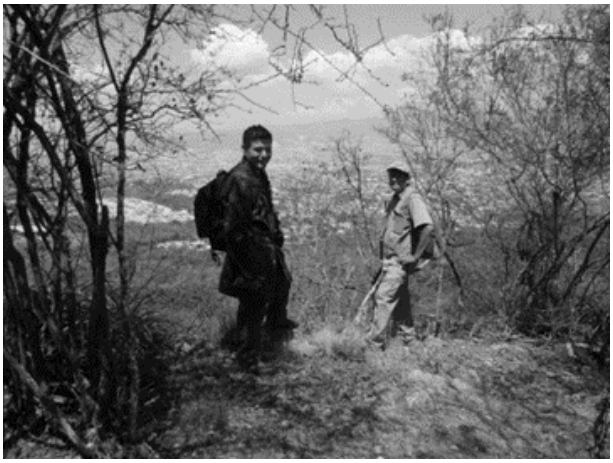
Figure 1

A female black jaguar (Panthera onca) in the ZOOMAT

Note. Source: Authors.

Figure 2

The highest place of NPA el Zapotal (south zone) near Tuxtla Gutiérrez



Note. Source: Authors.

Results

Perception

One hundred percent (n=17, N=17) of the collaborators viewed NPA el Zapotal positively because they believe it has a high environmental value and is necessary for safeguarding the environment, particularly the existing trees and animals they observe daily in the NPA vicinity (Table 2).

For example, collaborator four comments:

> It is very useful it is the only area that protects the riparian environment here of the stream or of the several streams that there are, of several springs that are in the zoo, as well as a refuge for wildlife that was displaced by the city, so it is critical.

Collaborator 13 states:

> Yes, it is useful, son, because, well for me, it is useful because it gives us oxygen, the freshness, the water, you know. Imagine, people living there in the downtown feel a lot of sun, heat, and here no, here we are in glory thanks to God, until now we are in glory.

On the other hand, 41% (n=7, N=17) of the people who have lived there for more than 60 years notice that there is now more vegetation cover (presence of tree species) within el Zapotal, while other people (35%, n=6, N=17), who have stayed there for 30 years perceive a decrease in the number of trees over the years. The rest of the collaborators do not perceive differences in this aspect (24%, n=4, N=17). Regarding the perception that the surrounding population has of the faunal species of el Zapotal, 59% (n=10, N=17) perceive the presence of fewer animal species within the NPA at present; 29% (n=5, N=17) notice more species, and only 12% (n=2, N=17) indicate that there is no difference in the number of species over the years (Table 2).

Table 2

Collaborators' perception of el Zapotal and its flora and fauna species

Collaborator	Age	About NPA	About flora	About fauna
1	21	Positive	Does not perceive any changes	Does not perceive any changes
2	30-35	Positive	Increased	Perceives fewer species
3	59	Positive	Increased	Perceives fewer species
4	ND	Positive	Decreased	Perceives fewer species but there are also new ones
5	46	Positive	Does not perceive any changes	Does not perceive any changes
6	30	Positive	Decreased	Perceives fewer species
7	29	Positive	Decreased	Perceives fewer species
8	50	Positive	Decreased	Perceives fewer species
9	78	Positive	Increased	Perceives more species
10	62	Positive	Does not perceive any changes	Perceives fewer species
11	51	Positive	Decreased	Perceives more species
12	56	Positive	Increased	Perceives fewer species
13	59	Positive	Decreased	Perceives fewer species
14	30	Positive	Decreased	Perceives fewer species
15	64	Positive	Increased	Perceives more species
16	69	Positive	Increased	Perceives more species
17	59	Positive	Increased	Perceives fewer species

Source: own elaboration.

Traditional ecological knowledge

One hundred percent (n=17, N=17) of the collaborators claim to have some TEK about various species of flora and fauna present in el Zapotal (Table 3 and Table 4).

Seventy-one percent (n=12, N=17) of the collaborators identified 24 flora species in el Zapotal, recognizing their common names. The most mentioned species are mango (*Mangifera indica*) (seven mentions), sapodilla (*Manilkara zapota*) (six mentions), black nightshade (*Solanum americanum*) (four mentions), and chipilín (*Crotalaria longirostrata*) (three mentions). Eighty-eight percent (n=15, N=17) of the collaborators identified 13 species of fauna in the NPA, indicating their common names. The most mentioned animals are the agouti (*Dasyprocta punctata)* and the white-tailed deer (*Odocoileus virginianus*), with six mentions each, the plain chachalaca (*Ortalis vetula*) and the green iguana (*Iguana iguana*), with five mentions each, and the howler monkey (*Alouatta palliata*), with four mentions.

For example, contributor nine notes: “well, here there was a lot, there is, there is a lot of mango, sapodilla, the mango, the black sapote, the red sapote, ha!... and the coconut, there was also a coconut palm”.

Collaborator five indicates:

> We collected the red sapote, the sapodilla. There is a fruit called breadnut, yes, and this, but there was still permission to go inside and take fruits. Well, yes, it was sold because, as it was uncovered, it had no owner.

Regarding the TEK on distribution (where the species have been sighted or their location is known), feeding (what the species are known to consume in their daily diet or have been seen eating a particular species of flora or fauna), and behavior (what is known about how they behave in their environment, e.g., whether they are nocturnal or diurnal; if prefer to walk among trees or on the ground) of these species of flora and fauna, 94% (n=16, N=17) of the collaborators identify fundamental aspects of where the plant and animal species are found within the NPA; 94% (n=16, N=17) of the collaborators indicate what particular species of fauna feed on within the NPA, and 47% of collaborators (n=8, N=17) provide data on the behavior or conduct of certain species of fauna.

For example, collaborator 13 asserts:

> At least here in my house, I have a dog and my chickens. Sometimes they (plain chachalacas) do not come close, and if they come in the mornings, the noise of the plain chachalacas from the reserve, to eat what there is, little corn, whatever.

Collaborator 16 comments: “the deer, the tender shoots, since the zoo has given them, well, their maize and their food, they have adapted, but normally they eat shoots, seeds.”

Table 3

Flora and fauna species recorded, and their local and scientific names

Collaborators		Species	
		Scientific name	**Common name**
1	Plant	*Persea americana*	Avocado
		Hamelia patens	Firebush
	Animal	*Sylvilagus floridanus*	Eastern cottontail
		Iguana iguana	Green iguana
		Ortalis vetula	Plain chachalaca
2	Plant	*Brosimum alicastrum*	Breadnut
	Animal	*Iguana iguana*	Green iguana
3	Animal	*Dasyprocta punctata*	Central American agouti
		Sylvilagus floridanus	Eastern cottontail
		Odocoileus virginianus	White-tailed deer
4	Plant	*Mangifera indica*	Mango
		Manilkara zapota	Sapodilla
		Solanum americanum	American black nightshade
		Crotalaria longirostrata	Chipilín
	Animal	*Dasyprocta punctata*	Central American agouti
		Dasypus novemcintus	Nine-banded armadillo

		Crax rubra	Great curassow
		Penelopina nigra	Highland guan
5	Plant	*Crotalaria longirostrata*	Chipilín
		Solanum americanum	American black nightshade
		Piper auritum	Mexican pepperleaf
6	Plant	*Mangifera indica*	Mango
		Manilkara zapota	Sapodilla
	Animal	*Sciurus aureogaster*	Red-bellied squirrel
		Iguana iguana	Green iguana
		Dasyprocta punctata	Central American agouti
		Micrurus browni,	Brown's coral snake
		Alouatta palliata	Mantled howler monkey
7	Plant	*Gliricidia sepium*	Mexican lilac
		Mangifera indica	Mango
		Melicoccus bijugatus	Spanish lime
		Tamarindus indica	Tamarind
		Annona muricata	Soursop
		Annona diversifolia	Ilama tree
		Cnidoscolus aconitifolius	Chaya
		Chenopodium ambrosioides	Mexican tea
		Solanum americanum	American black nightshade
	Animal	*Odocoileus virginianus*	White-tailed deer
		Pteroglossus torquatus	Collared aracari
8	Animal	*Odocoileus virginianus*	White-tailed deer
		Dasyprocta punctata	Central American agouti
9	Plant	*Mangifera indica*	Mango
		Manilkara zapota	Sapodilla
		Coconuts nucifera	Coconut
		Crotalaria longirostrata	Chipilín
		Amaranthus hybridus	Slim amaranth
		Portulaca oleracea	Common purslane
		Unidentified	Wood
		Various species	Mushrooms
	Animal	*Ctenosaura similis*	Spiny-tailed iguana
10	Plant	*Ricinus communis*	Castor bean
		Unidentified	Aceituna
		Manilkara zapota	Sapodilla
		Mangifera indica	Mango
11	Plant	*Manilkara zapota*	Sapodilla
		Mangifera indica	Mango
		Spondias purpurea	Jobo/Hobo/Jocote Amarillo
		Manilkara zapota	Sapodilla
	Animal	*Ortalis vetula*	Plain chachalaca
		Alouatta palliata	Mantled howler monkey
		Dasyprocta punctata	Central American agouti
		Sciurus aureogaster	Red-bellied squirrel
12	Animal	*Alouatta palliata*	Mantled howler monkey
		Ortalis vetula	Plain chachalaca
13	Animal	*Alouatta palliata*	Mantled howler monkey
		Dasyprocta punctata	Central American agouti
		Ortalis vetula	Plain chachalaca
14	Animal	*Odocoileus virginianus*	White-tailed deer
15	Plant	*Manilkara zapota*	Sapodilla
		Mangifera indica	Mango

		Pouteria sapota	Mamey sapote
		Diospyros digyna	Black sapote
	Animal	*Odocoileus virginianus*	White-tailed deer
		Ortalis vetula	Plain chachalaca
		Iguana iguana	Green iguana
16	Plant	*Solanum americanum*	American black nightshade
		Crotalaria longirostrata	Chipilín
	Animal	*Odocoileus virginianus*	White-tailed deer
17	Plant	Unidentified	Gamuza
		Portulaca oleracea	Common purslane
		Amaranthus hybridus	Slim amaranth
	Animal	*Iguana iguana*	Green iguana

Source: own elaboration.

Table 4

TEK on flora and fauna of NPA el Zapotal

Collaborators		Species	Feeding	Distribution	Behavior
1	Flora	Avocado	ND	Along the perimeter of the NPA	ND
		Firebush	ND	ND	ND
	Fauna	Eastern cottontail	ND	ND	ND
		Green iguana	Fruits within the reserve	Throughout the NPA	Perches on trees
		Plain chachalaca	ND	Throughout the NPA	ND
2	Flora	Breadnut	ND	ND	ND
	Fauna	Green iguana	Fruits, leaves, insects	Inside and outside the NPA	Everywhere; no specific place
3	Fauna	Central American agouti	Fruits that fall from trees (sapodilla, mango)	Throughout the NPA	ND
		Eastern Cottontail	ND	Throughout the NPA	ND
		White-tailed Deer	ND	Throughout the NPA	ND
4	Flora	Mango	ND	ND	ND
		Sapodilla	ND	Throughout the NPA	ND
		American black nightshade	ND	ND	ND
		Chipilín	ND	ND	ND
	Fauna	Central American agouti	Fruits that fall from trees	Throughout the NPA	ND
		Nine-banded armadillo	ND	Throughout the NPA	Nocturnal
		Great curassow	ND	Throughout the NPA	ND

		Highland guan	ND	Throughout the NPA	ND
5	Flora	Chipilín	ND	Around the central plaza of the NPA (ZOOMAT plaza)	ND
		American black nightshade	ND	Throughout the NPA	ND
		Mexican pepperleaf	ND	Throughout the NPA	ND
6	Flora	Mango	ND	ND	ND
		Sapodilla	ND	ND	ND
	Fauna	Red-bellied squirrel	Almonds, melon, tree fruits	ND	ND
		Green iguana	Fruits	ND	ND
		Central American agouti	Fruits	ND	ND
		Firebush	ND	ND	ND
		Mantled howler monkey	Fruits	ND	ND
7	Flora	Mexican lilac	ND	Throughout the NPA	ND
		Mango	ND	ND	ND
		Spanish lime	ND	ND	ND
		Tamarind	ND	ND	ND
		Soursop	ND	ND	ND
		Chaya	ND	ND	ND
		Mexican tea	ND	ND	ND
		American black nightshade	ND	ND	ND
	Fauna	White-tailed deer	Fruits, leaves	Throughout the NPA	ND
		Collared aracari	Fruits	Throughout the NPA	Perches on trees
8	Fauna	White-tailed deer	Fruits, leaves	Within the perimeter inside the NPA fence, towards Patricia Park	ND
		Central American agouti	Fruits, leaves	Inside the NPA	ND
9	Flora	Mango	ND	ND	ND
		Black sapote	ND	ND	ND
		Red sapote	ND	ND	ND
		Coconut	ND	ND	ND
		Chipilín	ND	Near to the hill (upper part of the NPA)	ND

		Slim amaranth	ND	Near to the hill (upper part of the NPA)	ND
		Common purslane	ND	ND	ND
			ND	ND	ND
	Fauna	Spiny-tailed iguana	Fruits	Throughout the NPA	ND
10	Flora	Castor bean	ND	ND	ND
		Olive	ND	ND	ND
		Sapodilla	ND	Throughout the NPA	ND
		Mango	ND	Throughout the NPA	ND
11	Flora	Sapodilla	ND	Patricia Park, central part of the NPA	ND
		Mango	ND	Patricia Park, central part of the NPA	ND
		Ovo	ND	ND	ND
	Fauna	Plain chachalaca	ND	Patricia Park, surroundings of the NPA	ND
		Mantled howler monkey	Fruits	Throughout the NPA	ND
		Central American agouti	Fruits	Throughout the NPA	ND
		Red-bellied squirrel	Fruits	Throughout the NPA	ND
12	Fauna	Mantled howler monkey	Fruits	Inside the NPA	ND
		Plain chachalaca	Fruits	Around the NPA, adjacent to the perimeter fence	Perched in trees, forages for food early in the day
13	Fauna	Mantled howler monkey	Fruits, seeds	Throughout the NPA	ND
		Central American agouti	Fruits, seeds	Throughout the NPA	ND
		Plain chachalaca	Fruits, seeds	Within the containment perimeter of the NPA, adjacent to my house	Comes to forage for food early in the day
14	Fauna	White-tailed deer	Leaves	Various sites along the NPA edge	It is observed more in the afternoons, when there are fewer people
15	Flora	Sapodilla	ND	Throughout the NPA	ND
		Mango	ND	Throughout the NPA	ND
		Red sapote	ND	Throughout the NPA	ND
		Black sapote	ND	Throughout the NPA	ND
	Fau	White-tailed deer	Leaves	Along the inner edge of the NPA	Visible in sunny afternoons, early in the day

	na	Plain chachalaca	Fruits	Along the inner edge of the NPA	Visible in sunny afternoons, early in the day
		Green iguana	Fruits	Along the inner edge of the NPA	Visible in sunny afternoons, early in the day
16	Flora|Fauna	American black nightshade	ND	ND	ND
		Chipilín	ND	ND	ND
		White-tailed deer	Corn, seeds	Throughout the NPA	ND
17	Flora	Gamuza	ND	ND	ND
		Common purslane	ND	ND	ND
		Slim amaranth	ND	Central part of the NPA	ND
	Fauna	Green iguana	Fruits	Throughout the NPA	ND

Note. ND: no data. Source: own elaboration.

Uses

Some 76% (n=13, N=17) of the collaborators stated that they used particular flora and fauna species found within el Zapotal. Flora and fauna were predominantly taken for food, medicine, and firewood (Table 5).

Among the most frequently used flora species were mango and sapodilla (six mentions each) and American black nightshade (four mentions); among the most used fauna species are eastern cottontail (two mentions) and iguana (one mention).

For example, contributor one commented:

> For headaches, I know that... the leaf is called, well, avocado. It is not eaten!, that only she (her grandmother) gave us to calm us down. Or, when a woman has a lot of pain, for when she has her period, she makes us a tea. That tea has no flavor, but it helps us to calm down any pain. We do not eat it, but she gives it to us as a remedy.

Meanwhile, collaborator nine indicated:

> Since my people here are, well, we are natives from here, we are humble people and, for the tortillas because before there were no tortilla shops around here, tortillas were made by hand, for everything, for the food, for everything the wood was valuable. Right now, it's reserved, right now, you can't just easily cut down a tree, everything is reserved now! Before you could go in with your machete and your axe to collect wood, look for your little wood and it was fine, there was no problem, it was free.

Table 5

Uses of flora and fauna present in el Zapotal

Collaborator		Species	Uses
1	Plant	Avocado	Medicinal (headaches)
		Firebush	Medicinal (menstrual pain)
	Animal	Eastern cottontail	Food
		Green iguana	ND
		Plain chachalaca	ND

2	Plant	Breadnut	Food
	Animal	Green iguana	Food
3	Animal	Central American agouti	ND
		Eastern cottontail	Food
		White-tailed deer	ND
4	Plant	Mango	Food
		Sapodilla	Food
		American black nightshade	Food
		Chipilín	Food
	Animal	Central American agouti	ND
		Nine-banded armadillo	ND
		Great curassow	ND
		Highland guan	ND
5	Plant	Chipilín	Food
		American black nightshade	Food
		Mexican pepperleaf	Food
6	Plant	Mango	Food
		Sapodilla	Food
	Animal	Red-bellied squirrel	ND
		Green iguana	ND
		Central American agouti	ND
		Brown's coral snake	ND
		Mantled howler monkey	ND
7	Plant	Mexican lilac	ND
		Mango	Food
		Spanish lime	Food
		Tamarind	Food
		Soursop	Food
		Ilama tree	Food
		Chaya	Food
		Mexican tea	Food
		American black nightshade	Food
	Animal	White-tailed deer	ND
		Collared aracari	ND
8	Animal	White-tailed deer	ND
		Central American agouti	ND
9	Plant	Mango	Food
		Black sapote	Food
		Red sapote	Food
		Coconut	Food

		Chipilín	Food
		Slim amaranth	Food
		Common purslane	Food
		Wood	Firewood
		Mushrooms	Food
	Animal	Spiny-tailed iguana	Food
10	Plant	Castor bean	Food
		Olive	Food
		Sapodilla	Food
		Mango	Food
11	Plant	Sapodilla	Food
		Mango	Food
		Ovo	Food
		Sapodilla	Medicinal (to regulate blood sugar level)
	Animal	Plain chachalaca	ND
		Mantled howler monkey	ND
		Central American agouti	ND
		Red-bellied squirrel	ND
12	Animal	Mantled howler monkey	ND
		Plain chachalaca	ND
13	Animal	Mantled howler monkey	ND
		Central American agouti	ND
		Plain chachalaca	ND
14	Animal	White-tailed deer	ND
	Plant	Sapodilla	Food
15	Plant	Mango	Food
		Red sapote	Food
		Black sapote	Food
	Animal	White-tailed deer	ND
		Plain chachalaca	ND
		Green iguana	ND
16	Plant	Chipilín	Food
		American black nightshade	Food
			ND
	Animal	White-tailed deer	Food
17	Plant	Common purslane	Food
		Slim amaranth	Food
	Animal	Green iguana	ND

Note. ND: no data. Source: own elaboration.

Discussions

The positive local awareness of el Zapotal suggests that the inhabitants surrounding this area feel that the existence of the NPA is valuable for protecting the environment. This perception seems to be deeply rooted as collaborators point out that the function of this area lies in protecting the forest cover, which is of immeasurable worth for looking after the environment; for example, collaborators state that this canopy protection allows them to bask in a more bearable ambient temperature in the surroundings of el Zapotal compared to that of the city center. Documenting this perception is essential to understanding the context of environmental problems in this NPA and establishing adequate management plans, given that it is necessary to involve the neighboring inhabitants. As Cáceres *et al.* (2023) suggest, before comprehending the environmental issue, it is imperative to record the environmental perceptions of the individuals and collectives that constitute a population since they shape the attitude, sensitivity, and influence actions towards the environment.

Regarding the results on the TEK of flora and fauna in NPA el Zapotal, many collaborators report knowledge of different species of plants and animals existing there and on ecological aspects of their distribution, feeding, and, to a much lesser extent, their behavior (fauna). Following González and Argueta (2018, p. 15), "the importance of TEK lies, in the first place, in the inclusion of wild plants and animals that guarantee a large part of the life of local communities," suggesting that it is likely that the TEK of these individuals is of those species they use the most.

Although the collaborators reported TEK with no details of each aspect, they show a clear awareness of the existence of 24 species and some data on their ecology. It is noteworthy that most of the contributors agree in mentioning the same species due to the knowledge acquired by empirical learning or teachings from older generations, creating a collective set of TEK; in this regard, Muñoz-Rojas *et al.* (2019, p. 242) point out that "these characteristics of collectivity and integrality of traditional knowledge are fundamental for understanding their nature and for searching mechanisms of protection." We understand, therefore, that the body of TEK rescued in this study, although limited, belongs to the coexisting neighborhoods of el Zapotal. In addition, it should be understood that the set of beliefs and own knowledge is intertwined with the TEK since its veracity and validity lie in the observation, analysis, and constant interaction with the natural environment (Jasso, 2019), implying that, on the one hand, “these knowledge put into social practice are: cognitive, agricultural, economic, educational, recreational, and even religious” practices (Melo, 2019, p. 242).

On the other hand, the collaborators claim to use different species of flora and fauna, especially for food, such as mango, sapote, eastern cottontail, or the iguana, and they also use some plants for medicinal purposes, such as the American black nightshade and sapodilla, or for firewood, such as the tree. Regarding hunting activity, contributors did not want to comment on it, and this activity was also not recorded during participant observation; however, some park rangers provided indirect information through conversations, noting which species have been recent victims of hunting (white-tailed deer, eastern cottontail, Central American agouti), agreeing with Álvarez and Heider (2019), who state that this practice is still observed in rural and semi-urban areas. Nevertheless, park rangers and local police state that hunting is prohibited in the reserve and that the el Zapotal vicinity is under constant surveillance.

These harnessing activities demonstrate basic knowledge of flora and fauna in the area and how "currently, natural resources are utilized by human beings to satisfy their subsistence needs, such as food, health, economic, and leisure" (Orellana & Lalvay, 2018, p. 66). Besides, such uses, in particular cases, often yield insights that help to understand the meanings and cultural value of a community, as they enable the identification of models in biodiversity management and the integration of issues such as biocultural education for conservation and sustainable use (Gasca & González, 2021). Furthermore, studies and records "have shown that the use of wild flora and fauna varies over time and space, as it is intrinsically related to cultural habits, lifestyles, and ecosystem management practices" (Ávila-Nájera, *et al*., 2018, p. 2). These findings harmonize with the descriptions of the collaborators, who mention that, in time, the types of species employed have changed, with the use of plants now being more common than that of animals. Finally, it is worth mentioning that the collaborators report that these cultural practices of use and exploitation of flora and fauna in the reserve have ceased, not only because it is an NPA but also due to the urban context in which they currently live, schooling, and salaried work, leading to the loss and reduction of these practices, while modern urban life generates new needs (Beuf, 2020).

Conclusions

The results of the ethnoecological analysis indicate that the individuals cohabiting with NPA el Zapotal perceive it positively and so the fauna and flora that inhabit it, thereby accepting the proposed hypothesis.

The collaborators have TEK about the fauna and flora of the NPA, supporting the related hypothesis. They identified 24 species and some ecological processes such as distribution, feeding, and behavior. Even though the TEK needs to be more detailed and profound in these matters, it demonstrates basic knowledge.

The people living near el Zapotal use several species of flora and fauna, either for consumption (food), medicinal purposes, or firewood; so, the hypothesis proposed at the beginning of the research is also accepted. No direct evidence of poaching was found, but it is essential to mention that it was reported.

Finally, it is essential to update the management program of the reserve to reflect the perception, uses, and TEK of the inhabitants of the surrounding neighborhoods to approach sustainability. To this end, the NPA administration should establish linkage programs with the residents, including ongoing environmental education and their involvement in the management and cleaning of the areas adjacent to the reserve, as well as the creation of a group of volunteer neighbors in charge of constantly monitoring the perimeter to promote the protection of el Zapotal.

It is recommended to work on this type of study because the perception, the TEK, and the uses given to the flora and fauna are not unchangeable but constantly transform. It is also essential to conduct regular monitoring of the NPA.

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Conflict of interest

The authors do not manifest a conflict of interest of any type.

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