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Ecological Knowledge and Management of Fauna Among the *Mexicatl* of the Sierra Negra, México: An Interpretive Approach

Mariana Zarazúa-Carbajal[1,2], *Michelle Chávez-Gutiérrez*[1], *Juan Luis Peña-Mondragón*[1] *and Alejandro Casas*[1]*

[1] *Laboratorio de Manejo y Evolución de Recursos Genéticos, Instituto de Investigaciones en Ecosistemas y Sustentabilidad, Universidad Nacional Autónoma de México, Morelia, Mexico,* [2] *Posgrado en Ciencias Biológicas, Universidad Nacional Autónoma de México, Mexico City, Mexico*

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***Correspondence:**
Alejandro Casas
acasas@cieco.unam.mx

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Generally motivated by the relevance of animals in human subsistence, the management of fauna has taken different shapes throughout the world. This study aims to analyse a typology of management forms, exploring their relationship with the motivation to maintain coexistence and use of fauna and mitigate negative human-fauna interactions by the *Mexicatl* (Nahua) people in Central Mexico. We generally expected to find a broad spectrum of management types in a gradient of interactions intensity. This is because we hypothesised that the more meaningful these interactions due to the magnitude of benefit or damage, philias, or phobias among other positive or negative perceptions, and ecological aspects and management viability, the more actions and practices might be motivated to maintain or mitigate them. We conducted a qualitative research based on interpretivist approaches, mixing qualitative and quantitative analyses, to register the *Mexicatl* names of fauna present in the area and recognised by locals and to analyse the influence of local ecological knowledge (LEK) and natural history as perceived by people on the use, conflicts, and management practices regarding local fauna. In order to gather such information, in 2018 and 2019 we generated 356 free lists of fauna and 20 sessions of group interviews about the presence of animals in the area, the *Mexicatl* name, information on distribution, diet, use, management, and other facts. We used visual stimuli with children and young people from schools of basic and intermediate levels in five rural communities and the municipal head of Coyomeapan, Puebla. We also generated free lists and in-depth interviews with 18 persons older than 16 years. People recognised 114 animal items, the most salient being 11 domestic and 14 wild animals including deer, medium and small mammals, snakes, and birds. For both domestic and wild fauna, people reported 18 use categories and three types of damage (crop losses, predation of domestic animals, and damages to health). LEK interacted with traditional celebrations, religious beliefs, land tenure, and migration to define preferences and management types of fauna. Bushmeat demand, especially for *Mazama temama* and *Cuniculus paca,* was related to a perception of healthy nutrition properties. Management actions included husbandry of domestic animals, extraction

of wild animals for supply, or to avoid damages, captivity, tolerance to damage, protection of seeds and domestic animals threatened by wild fauna, regulations for extraction of wild fauna, and agreements to prevent conflicts. Mixed quantitative and qualitative approaches allowed the interpretation of the human-fauna interactions related to subsistence, coexistence, and the high relevance of LEK, perceptions, religious beliefs, ecosystem, socio-demographic factors, and animal behaviour and habits, which are crucial factors that influence the shaping of management practices. Local management strategies of fauna were diverse and contribute to biocultural conservation and theoretical construction on domestication.

Keywords: ethnozoology, wildlife, worldview, local ecological knowledge, animals management, traditional ecological knowledge, humans-animals coexistence, subsistence

INTRODUCTION

Management actions are concrete expressions of worldviews of human individuals or societies. It involves decisions on elements and/or processes of ecosystems at several scales to use, conserve, and/or restore them (Casas et al., 2016). Management of fauna populations may involve decisions on animals' ecological partners, such as host plants, diet elements, or abiotic elements of their habitat (Ojasti, 2000; Zeder, 2015) to ease obtention, ensure the availability of animals (Zeder, 2015), or to deliberately reduce their populations (Ojasti, 2000; Sinclair et al., 2006).

Fauna management actions are based on the several corpuses of place-based, local empirical knowledge that accumulated, evolved through time, and incorporated Western scientific and conservation biology principles (Sánchez, 1999). Local ecological knowledge (LEK) (or traditional ecological knowledge *sensu* Berkes, 2008) is adaptive information (i.e., knowledge, beliefs, values, symbols, techniques, and practices) about the interactions of living beings, including humans, with others and their environment that is transmitted through generations (Berkes, 2008). Local management may, or may not, be enough to allow the viability of fauna populations and their habitats, especially when external pressures (i.e., global, national) cause the deterioration of quality of life and environment, and the collapse of local institutions (Ostrom et al., 1999; Agatha, 2016), including the mechanisms of LEK adaptation and transmission (Fernández-Llamazares and Reyes-García, 2016). However, research on local management practices that likely do it, including technology, decision making (Ostrom et al., 1999), and the favourable social institutions and conditions that allow this management to occur, should enlighten conservation strategies (Casas et al., 2016).

Fauna plays complex roles in human life. People engage in affective or even religious relations with animals. They recognise their intrinsic value or consider them in their ecological dimension. However, humans also appreciate fauna in a utilitarian sense or relate it to factors of damage. Animals have provided food, medicine, company as pets, ornaments, traction, transport, materials to manufacture tools or shelter, entertainment, amulets, and symbols of status, religion, belonging to a group (Nóbrega-Alves, 2012; Nóbrega-Alves and Albuquerque, 2018), or offering in ceremonies (López-Austin, 1999; Willerslev and Vitebsky, 2014; Santos-Fita et al., 2015). Animals may also be bioindicators about changes in weather (Rivero-Romero et al., 2016; Nóbrega-Alves and Duarte-Barboza, 2018) and human health (Nóbrega-Alves and Albuquerque, 2018). In addition, animals, trained or not, can help to obtain other animals in hunting or fishing (Santos-Fita et al., 2012; Pinto et al., 2018). Nevertheless, fauna may also transmit diseases, compete with humans for food, or be poisonous and harmful, which can sometimes result in human lethal actions towards fauna populations (Marchini, 2014).

Negative interactions between humans and wildlife occur when requirements and behaviour of the latter have negative impacts on human agenda, or vice versa (Madden, 2004). Human conflict can also arise when groups of people disagree regarding the animals' management (Marchini, 2014). For instance, while some persons or human groups involved in the management of a socio-ecological system consider that they receive a benefit due to the presence of an animal, others may consider it as harmful (Ceausu et al., 2018). But both conflicts and conditions to achieve human-fauna coexistence may be managed (Madden, 2004), and attending to them has become a main challenge for biodiversity conservation.

Coexistence is mediated through ecological, cultural, economic, and social dimensions. Therefore, it cannot be universally defined (Knox et al., 2020). However, this concept has been proposed (Madden, 2004) to integrate the management of human-wildlife and human-human reaction to conflicts in a way that ensures the long-term viability of populations of both humans and wildlife. Coexistence considers the ability to share a landscape in space and/or time, the human tolerance towards the damages caused by wildlife (Lute and Carter, 2020), the learning and changes in behaviour from both wildlife and humans, and the presence and legitimacy of social institutions, including formal and informal rules that regulate reaction to conflicts (Carter and Linell, 2016).

The purpose of our research was to analyse how LEK, human perceptions of fauna, and ecological aspects and habits of animals interact to shape the types of management practices by the *Mexicatl* people towards wild and domestic fauna, for satisfying subsistence needs and human-fauna coexistence. We analysed these aspects in a context in which people live close to forests and heavily depend on biotic and agricultural resources to live

and continually make decisions towards fauna on their daily life. We aimed to answer the following questions: (1) Which wild and domestic animals are relevant to people in their human-influenced and wild environments? (2) Which needs use animals for satisfaction? Which animals are used to satisfy these needs?; (3) Which animals cause damages? What specific damage(s) do they cause? (4) How do people manage animals? (5) Which management choices, based on LEK, allow the human-fauna coexistence? and (6) How do human-fauna interactions differ among villages located in different ecosystems?

We generally expected that LEK plays a major role in the management practices engaged to ensure the availability of useful fauna and to mitigate human-fauna negative interactions or human-human conflicts that could arise in relation to animals. In addition, other factors related to ecological aspects, behaviour, and habits of animals influence how the interactions and management are.

MATERIALS AND METHODS

Study Area

The municipality of Coyomeapan is located in the portion of the Sierra Madre Occidental known as Sierra Negra in the state of Puebla, México. It is part of the area of influence of the Tehuacán-Cuicatlán Biosphere Reserve (Secretaría de Medio Ambiente y Recursos Naturales-Comisión Nacional de ÁĄreas Naturales Protegidas [SEMARNAT- CONANP], 2013). We conducted our work in Santa María Coyomeapan, an urban nucleus with 1,288 people (Instituto Nacional de Estadística, Geografía e Informática [INEGI], 2020) and in four *Mexicatl* rural communities. The village of Aticpac, with 160 inhabitants (Instituto Nacional de Estadística, Geografía e Informática [INEGI], 2020), is located in the transition between semi-evergreen tropical forest, cloud forest, and pine forest. The village is settled in an area locally known as "Tierra Caliente" (TC), which includes the villages of Ahuatla, Caxalli, and Ixtlahuac with 554, 216, and 431 inhabitants, respectively (Instituto Nacional de Estadística, Geografía e Informática [INEGI], 2020), are located in the pine forest area, which in this manuscript will be referred to as "Sierra." People's subsistence mainly relies on the agroecosystem called *milpa* which includes maize, beans, and several species of edible weedy plants called *"quelites"* (Blancas et al., 2013). In the Sierra, crops also include apple, fava beans, chile canario (*Capsicum pubescens* Ruiz and Pav) and avocado, while in the TC, crops include sugarcane, banana, coffee, and tepejilote (*Chamaedorea tepejilote* Liebm.). Domestic animals raised include sheep (*Ovis aries* L.), goats (*Capra hircus* L.), pigs (*Sus scrofa* L.), chickens (*Gallus gallus* L.), and turkeys (*Meleagris gallopavo* L.). Familiar remittances from abroad are a considerable source of income; small commerce and low intensity tourism also occur. Trade of products from the different ecosystem regions is carried out in the plaza of Santa María Coyomeapan every Thursday and Sunday. Zoological and ethnozoological literature is scarce for the area, but previous work reported the presence of the American deer (*Mazama temama* Kerr) (Pérez-Solano et al., 2012), herpetofauna (Canseco and Gutiérrez, 2010; Linares-Rosas et al., 2021), and use reports of 13 mammals, snakes, and immature stages of Saturniidae and Hepialidae Lepidoptera (Zarazúa-Carbajal et al., 2020; Linares-Rosas et al., 2021; **Figure 1**).

Research Design

Our work incorporates insights from the grounded theory (Strauss and Corbin, 1998), ethnosciences (Argueta et al., 2012; Casas et al., 2016; Nóbrega-Alves and Albuquerque, 2018; Albuquerque et al., 2020), and fauna management (Ojasti, 2000; Sinclair et al., 2006; Zeder, 2006, 2015; Carter and Linell, 2016; Zarazúa, 2016; Ceausu et al., 2018; Zarazúa-Carbajal et al., 2020). We conducted exploratory qualitative research that allowed us to adopt an interpretive perspective from which the construction of multiple realities through social interaction is recognised. In addition, it allowed to show that the investigation was influenced by the researcher's own interpretations (Maxwell, 2013; Castillo et al., 2020). The information was generated through cultural domain and semi-structured interview techniques (Newing et al., 2011) and through direct observation of items and events. We included people of different profiles (women, men, specialised hunters, children, and teenagers) who use and manage animals and could show variation in their perspectives about fauna management to increase the internal validity of the analysis (Drury et al., 2011). Although the general approach is qualitative, we used both quantitative and qualitative analyses of the information.

Semi-Structured Interviews and Observation

From April 2018 to July 2019, we conducted workshops with 356 students aged 8–17 years old in groups of 15–40 students each in three elementary schools, two secondary schools, and one high school. Also, we carried out individual in-depth interviews with adults (>16 years old). Each workshop and interview started with a presentation of our research team that included the purposes of the project. We requested permission to take notes and/or audio recordings before each session. In workshops, we asked the students to write down, individually, a free list of the animals present in the community. Free lists included wild and domestic fauna items. We continued with a visual stimulus instrument consisting, in the projection, of photographs of animal species previously reported in the Tehuacán-Cuicatlán and the Sierra Negra regions. We asked the following about each animal: if it occurs in the area, its *Mexicatl* name, information on distribution, diet, use, management, and free additional facts. We conducted 11 workshops about mammals, four about domestic fauna, three about herpetofauna, two about insects, and one about birds (**Supplementary Additional Table 1** in Additional File 1). In each session, we carried out games (30–180 min each, depending on the interest of the group) in which we asked open questions about the damages an animal may cause.

Interviews with adults were carried out with 14 women and four men of 18 households from Ahuatla, Caxalli, and Aticpac (nine from the Sierra, and nine from the TC). They

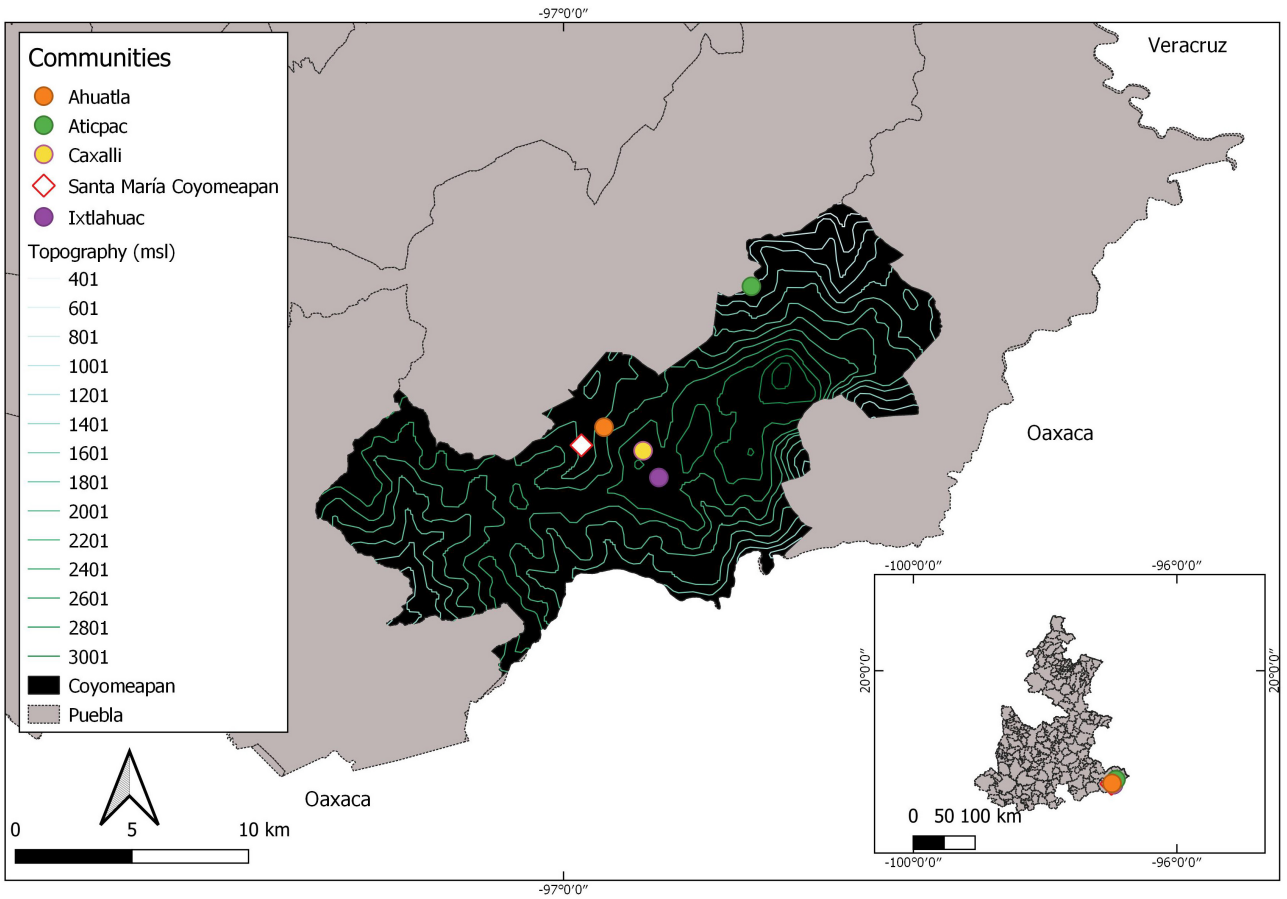

FIGURE 1 | Study Area. Rural communities are displayed as circles and the municipal seat as a square. Aticpac is classified as "Tierra Caliente" (TC) while Ahuatla, Caxalli, and Ixtláhuac as "Sierra." The Cerro del Tzintzintepetl (Tzintzintepetl Hill) is located in the highest elevation area between Aticpac and the Sierra communities. Figure elaborated in Quantum Geographic Information System (QGIS) (Open Source Geospatial foundation [OsGeo], 2020). with layers available from Geoportal Comisión Nacional para la Biodiversidad (CONABIO, 1998; Ávila-Blomberg and Moreno-Díaz, 2008; Instituto Nacional de Estadística, Geografía e Informática [INEGI], 2018).

recognised themselves as *Mexicatl* and were bilingual *Mexicatl*–Spanish speakers, native from their villages or living there for at least 15 years. Their main economic activities are agriculture and animal husbandry, but some of them have complementary occupations. We started asking an oral free list of the wild animals present in the community, prioritising mentions of wild animals that would be more difficult to be directly observed by visitors compared with domestic animals. Afterwards, we performed a semi-structured in-depth interview, with open questions about nomenclature, distribution, diet, use, conflicts, and management (**Supplementary Additional Table 2** in Additional File 1). We added questions to deepen information or when new subjects arose. Printed photographs of the animals or its display on a laptop screen were used to relate an animal to its taxonomic identity and to stimulate conversations. Additional information related to fauna management that arose from direct observation (i.e., demonstrations of management practices by people, hunting evidence such as skins or skulls) or informal conversations was registered in pictures and field diaries and used as a complementary source of data. When cited as sources of information throughout this manuscript, interviews to adult people are labelled as follows: (a) Sierra: D6, D7/8/9, D10, D11, D12, D13/28, D14, D25, D16, D18; and (b) TC: D5/23, D19, D20, D21, D22, D24, D25, D26, D27, while information from workshops with students is labelled D41 for the secondary school of the municipal head, D42 for the high school the municipal head, and D43 for Mariana Zarazúa (MZ) field diaries.

Data Analysis

Free Lists

Items were listed in Spanish and/or *Mexicatl*. Before the analysis, all items were homogenised in their written nomenclature to avoid synonyms. Male, female, and young animals of a given species were considered as one item (i.e., rooster, hen and chicken; male and female turkey). However, we maintained the distinction between creole turkey and farm turkey, butterfly and their immature stages, and between frog and tadpole. All free lists' analyses were performed using R 3.6.3 R software (2020) and R studio (2021).

We calculated the frequency of mention of each item, its average order of mention, and the Smith salience index, calculated as follows: $S = \left(\Sigma \frac{L-Rj+1}{L}\right) N$; where "L" is the length of the list, "R*j*" is the rank of item *j* in the list, and "N" is the number of lists (Smith and Borgatti, 1997) in accordance with da Silva et al. (2019). An item was considered salient if its Smith salience index value was above the average value for the group and if the probability that the value turned out by chance was less than 5% ($p < 0.05$). To calculate this probability per group, lists from 1,000 random populations with the same number of items and informants as the group were simulated using the Monte Carlo method (da Silva et al., 2019). To perform the analysis, we grouped the lists following age and provenance of people. At the first level, we grouped the students' overall lists (n = 356). Then, we grouped students' lists in eight sets according to their community of origin and school grade (elementary, 8–12 years old; secondary, 12–15 years old; and high school, 15–17 years old) to register the matches of the salient items among these eight sets. Free lists from adults were analysed by overall grouping ($n = 16$) on the first level and as two sets (TC and Sierra, 8 free lists each) on the second level.

We compared the total inventory of wild fauna items among age groups (adults, high school, secondary school, and elementary school students) and regions (Sierra, TC, municipal head) according to the presence/absence of data with an analysis of similarities (ANOSIM) using Jaccard distances ("anosim" function, package vegan, Rsoftware) (Oksanen et al., 2020). In a similar way, we compared the inventory of wild fauna salient items among age groups (adults vs. secondary school).

Salience, Use, and Conflict Reports

We built contingency tables with the counts of the listed items (students and adults separately), categorising variables according to the salience (salient or not salient), use (yes or not), and whether they cause damage (yes or not). We tested the independence between these variables with the Fisher's exact test (fisher.test function, R software).

Analysis of Natural History, Use, Conflict, and Management Typology

Audios and notes were transcribed, and the text was codified (Strauss and Corbin, 1998; Maxwell, 2013) by using the software ATLAS.ti 8 (2021). Codes were grouped into categories (Maxwell, 2013; **Table 1**) and organised into a typology and a general scheme of fauna use and management.

TABLE 1 | Organisational categories and references of theoretical frames used for analysing the information generated in this research.

Category[a]	Definition (Number and percentage of mentions)[b]	References
Natural history (O)	Codes and categories relating to diet, life cycles, distribution or ecological interactions of used/managed fauna	NA
Fauna use (O)	Codes and categories describing use typology (155 mentions for 70 animals; 100%)	López-Austin, 1999; Nóbrega-Alves, 2012; Willerslev and Vitebsky, 2014; Santos-Fita et al., 2015; Rivero-Romero et al., 2016; Nóbrega-Alves and Albuquerque, 2018; Nóbrega-Alves and Duarte-Barboza, 2018; Pinto et al., 2018.
Food (T)	Meat, eggs, milk or other parts and products of an animal, except honey, are eaten (26%)	
Ornamental/ Exhibition (T)	The living animal, taxidermies, or parts of the animal's body such as skin or bone remains are displayed as an ornament or status symbol (18%)	
Medicine (T)	The animal or parts of the animal are used to treat illnesses or aid birth labour (14%)	
Pet (T)	The animal is kept alive as animal companion (7%)	
Tool (T)	Parts of the animal such as bones, shields, antlers, or products such as wax are used as an instrument to facilitate human work (6%).	
Commercialisation (T)	People obtain an income after selling the animal to a second user (6%)	
Recreational (T)	An animal or its parts are used for recreation (4%)	
Amulet (T)	An animal or its parts are worn, kept, or displayed for protection against illness, or for attract good fortune (4%)	
Bioindicator (T)	Animals that indicate changes in weather, through behaviour and/or other phenotypical traits (3.3%)	
Traction/transport (T)	An animal is used to carry weight, people or as a draught animal (2%)	
Gift/offering (T)	Animals used as food or a special gift for someone in dairy life or to the godparents "padrinos" in social celebrations such as weddings, or ritual ceremonies "vestir al difunto" (dress a deceased person), among others (turkey) (2%)	
Honey (T)	Use of the honey, generally with edible or medicinal purposes (1.3%)	

(Continued)

RESULTS

Free List Inventory, Frequency, Order, and Salience Analyses

Students' Free List

An inventory of 108 animal items was registered in 356 lists. Wild mammals represented 26.78% of the items followed by arthropods at 24.11%, birds at 19.96%, reptiles at 8.93%, amphibia at 3.57%, snail, and fish (one item each). All domestic animals

TABLE 1 | (Continued)

Category[a]	Definition (Number and percentage of mentions)[b]	References
Fertiliser (T)	Use of the animal faeces to improve growth and productiveness of the plants (1.3%)	
Pest control (T)	Use of the animal to reduce the presence of damaging insects or mice (1.3%)	
Souvenir (T)	Part of the animal is kept as a reminder of a place or event (1.3%)	
Surveillance (T)	The animal is kept for announcing the presence of someone in the house or to drive away damaging fauna (1.3%)	
Animal health (T)	Animals are used to treat or prevent animal illness (1.3%)	
Aid in hunting (T)	Animals are used to facilitate the hunt (0.65%)	
Fibres (T)	Use of the shelter of the animal for obtaining raw material to manufacture strings, clothing or others (0.65%)	
Damage caused by fauna (O)	Codes and categories describing damages caused by fauna to crops, domestic animals or human health (41 mentions for 36 animals; 100%)	Marchini, 2014
Crop damage (T)	Crop losses because the animals (wild or domestic) predate part of the plants, either foliage, roots, flowers, fruits, or seeds; it also includes behaviours such as plant removing while looking for insects (61%)	
Predation of domestic animals (T)	Animals kill or feed on domestic animals, causing death, wounds, or illness. These are mostly wild animals, but free ranging dogs are also included (24%)	
Damage to human health (T)	These include disease (i.e., rabies) transmission, ophidian accident, and stings or bites of animals considered as poisonous (14.6%)	
Damage to merchandise (T)	This was the case only for the stole of eggs from a small grocery store by *Bassariscus* sp. (<1%)	
Fauna management (O)	Codes and categories describing actions towards fauna, host plants or habitat, intended to use, conserve, restore, perform land planning, reduce damages caused by fauna or achieve coexistence.	Ostrom et al., 1999; Ojasti, 2000; Sinclair et al., 2006; Zeder, 2006, 2015; Casas et al., 2016; Carter and Linell, 2016; Zarazúa-Carbajal et al., 2020
Supply (T)	Practices for obtaining animals in order to use them. Includes: Hunting, wild fauna captivity, gathering, feeding of domestic animals, health of domestic animals, reproduction of domestic animals, cares towards domestic animals.	
Extraction for prevention (T)	Fauna extraction to prevent damages to other items or processes. Includes: Hunting, poisoning	
Prevention (T)	Damage prevention that does not involve fauna extraction. Includes: Cares towards domestic animals, drive away, crop protection	
Assume the loss (T)	Withdrawal from economic activities or tolerance to the damages caused by fauna, because damage prevention is not effective. Includes: Tolerance to damage, abandonment of an activity.	
Human conflict prevention (T)	Agreements between people to prevent or remediate human conflicts caused by fauna management. Includes: agreements about grazing, gathering, hunting, retribution for stallion.	
Conservation (T)	Regulations to fauna extraction. Includes: Agreements, rules, personal attitudes that could imply regulations to fauna extraction.	

(Continued)

TABLE 1 | (Continued)

[a]*O, organisational categories (general subjects of research, used for ordering the information and defined before the interviews) T, theoretical categories (allow to situate the information in an abstract framework; they are defined by the researcher, often arising from theoretical background) (Maxwell, 2013). NA, does not apply.*
[b]*Number of mentions for use and damage was calculated as the summatory of the number of categories mentioned for each animal, by all interviewed adults (n = 18). A given animal could have been mentioned by the same person for more than one use or damage category.*

(mammals and birds) represented the 15.75% In addition, this technique allowed the registry of two items that we did not expect within the animal cultural domain, the "chane" and the "duende" (two of several spiritual beings recognised by people as present in forests, sometimes tricky, specially to children), although its frequency was low (n = 2 each). The 24 items that were determined as salient included 11 domestic and 13 wild animals (eight mammals, two reptiles, two birds, and one butterfly). Although not salient, the items, namely, frog, racoon, and bee, also had Smith values above the mean (**Table 2**). **Table 3** shows a summary of the lists by school groups.

Adult People's Free Lists

A total of 48 wild items were listed by adults. Mammals represented the seven most salient items (squirrel, deer, rabbit, white-nosed coati, racoon, opossum, and armadillo) and 45.8% of the listed items. Reptiles and birds represented 20.83% in each of the listed items and arthropods the 10.41%. Although not salient, the items snake, peccary, paca, skunk, and dove had Smith index values above the mean (**Table 4** and **Supplementary Additional File 2**).

We did not find significant differences in the general wild animal inventory between age groups (adults vs. high school vs. secondary school vs. elementary school $R = 0.1364$, $p = 0.171$) or provenance (Sierra vs. Tierra Caliente vs. Municipal seat $R = 0.1798$, $p = 0.133$) for wild animal salient items between age groups (adults vs. secondary school $R = 0.75$, $p = 0.333$).

Salience, Use, and Conflict Reports

We rejected the independent null hypothesis between a higher salience and use reports for both students and adults (respectively, p-value < 0.05; p-value $= 0.01$). We also rejected

TABLE 2 | Smith salience index, mean position, and frequency of wild and domestic animal items in 356 students' free lists, with *p*-values.

Item in English	Item in Spanish[a]	Salience (Smith Index)	Salience *p*-value	Mean position	Mean position *p*-value	Frequency	Frequency *p*-value
rabbit	**conejo**	**0.584**	0	**5.1538**	0	**286**	0
dog	**perro**	**0.5039**	0	**5.3202**	0.0001	**253**	0
hen	**gallina**	**0.485**	0	**7.2028**	0.0246	**281**	0
cat	**gato**	**0.4725**	0	**6.4598**	0.002	**261**	0
snake	**serpiente**	**0.3874**	0	**7.083**	0.0173	**229**	0
squirrel	**ardilla**	**0.3641**	0	7.7293	0.0896	**229**	0
turkey	**guajolote**	**0.3459**	0	7.5743	0.0619	**202**	0
bird	**pájaro**	**0.3137**	0	7.6763	0.0796	**207**	0
deer	**venado**	**0.313**	0	7.4565	0.0464	**184**	0
horse	**caballo**	**0.2484**	0	8.1494	0.1984	**154**	0
lamb	**borrego**	**0.2168**	0	9.7267	0.1842	**161**	0
pig	**cerdo**	**0.2134**	0	9.6139	0.2189	**158**	0
mouse	**ratón**	**0.2028**	0	9.872	0.147	**164**	0
donkey	**burro**	**0.1896**	0	8.976	0.4676	**125**	0
cow	**vaca**	**0.1834**	0	11.6621	0.0023	**145**	0
armadillo	**armadillo**	**0.1698**	0	9.487	0.2617	**115**	0
lizard	**lagartija**	**0.1663**	0	9.9697	0.1262	**132**	0
eagle	**águila**	**0.1518**	0	9.2703	0.34	**111**	0
duck	**pato**	**0.1442**	0	8.8696	0.487	**92**	0
opossum	**tlacuache**	**0.1385**	0	**10.5849**	0.0369	**106**	0
goat	**chivo**	**0.1355**	0	**10.5926**	0.0362	**108**	0
butterfly	**mariposa**	**0.1189**	0	**11.6204**	0.0024	**108**	0
coyote	**coyote**	**0.1108**	0.0003	**6.9016**	0.0101	**61**	0.0151
gray fox	**zorra**	**0.1072**	0.0005	9.5946	0.2247	**74**	0
frog	rana	0.0864	0.0683	10.0968	0.1	**62**	0.0105
racoon	mapache	0.0732	0.3573	9.4038	0.2906	52	0.2001
bee	abeja	0.0724	0.3856	**13.4**	0	**70**	0.0002
fish	pez	0.0676	0.4438	**10.8148**	0.0209	54	0.1279
vulture	zopilote	0.0672	0.4305	**10.86**	0.0189	50	0.2988
spider	araña	0.0635	0.3025	9.9615	0.127	52	0.2001
ant	hormiga	0.0564	0.1157	13.2545	0	55	0.1002
hawk	gavilán	0.0531	0.0625	**10.5952**	0.0361	42	0.2854
gopher	tuza	**0.0475**	0.0173	**11.3256**	0.0053	43	0.3438
peccary	jabalí	**0.0433**	0.0056	9.1538	0.3892	**26**	0.0003
owl	búho	**0.0417**	0.0033	9.5	0.2583	**30**	0.0042
fly	mosca	**0.0403**	0.0023	10.0667	0.1057	**30**	0.0042
worm	gusano	**0.039**	0.0014	**12.9512**	0	41	0.2323
hummingbird	colibrí	**0.0347**	0.0002	**11.0435**	0.0117	**23**	0.0001
toad	sapo	**0.0314**	0	**11.9231**	0.0009	**26**	0.0003
skunk	zorrillo	**0.0306**	0	**15.7667**	0	**30**	0.0042
cricket	grillo	**0.0294**	0	10.3182	0.0645	**22**	0.0001
dove	paloma	**0.0283**	0	**12.7727**	0	**22**	0.0001
bat	murciélago	**0.0266**	0	**14.8485**	0	**33**	0.0181
woodpecker	pájaro carpintero	**0.0261**	0	**10.9412**	0.0152	**17**	0
owl	tecolote	**0.0223**	0	**11.6364**	0.0024	**22**	0.0001
wolf	lobo	**0.0218**	0	9.4667	0.2675	**15**	0
turtle	tortuga	**0.0208**	0	10	0.1207	**12**	0
earthworm	lombriz	**0.017**	0	**14.1875**	0	**16**	0
white nosed coati	tejón	**0.0167**	0	**11.9231**	0.0009	**13**	0
mole	topo	**0.0152**	0	10.2727	0.0711	**11**	0

(Continued)

TABLE 2 | (Continued)

Item in English	Item in Spanish[a]	Salience (Smith Index)	Salience *p*-value	Mean position	Mean position *p*-value	Frequency	Frequency *p*-value
ring tailed cat	*chicna*	**0.014**	0	9.1	0.4128	**10**	0
tadpole	renacuajo	**0.0137**	0	**11.1**	0.0102	**10**	0
grasshopper	chapulín	**0.0126**	0	**13.7**	0	**10**	0
mount cat	gato montés	**0.0113**	0	**5.4**	0.0001	**5**	0
snail	caracol	**0.0108**	0	**15.7**	0	**10**	0
Mexican alligator lizard	kuwishi	**0.0105**	0	**6.1667**	0.0007	**6**	0
iguana	iguana	**0.0093**	0	**11**	0.0135	**14**	0
rat	rata	**0.0091**	0	7.6667	0.0785	**6**	0
lice	piojo	**0.0089**	0	**15**	0	**9**	0
mosquito	mosco	**0.0079**	0	**13.7**	0	**10**	0
scorpion	alacrán	**0.0076**	0	**16.9**	0	**10**	0
poxokuili	*poxokuili*	**0.0069**	0	**13**	0	**5**	0
wessel	onza	**0.0068**	0	**12.1667**	0.0005	**6**	0
mule	mula	**0.0065**	0	8.75	0.4355	**4**	0
wasp	avispa	**0.0058**	0	15.8333	0	**6**	0
rattlesnake	cascabel	**0.0054**	0	**13.6**	0	**5**	0
tarantula	tarántula	**0.0054**	0	**2**	0	**2**	0
woodlouse	cochinilla	**0.0052**	0	**13.2**	0	**5**	0
paca	tepezcuintle	**0.005**	0	**7**	0.0138	**4**	0
raven	cuervo	**0.0049**	0	**12.6667**	0	**3**	0
margay	tigrillo	**0.0044**	0	8	0.1565	**2**	0
peacock	pavo real	**0.0041**	0	**12.6**	0.0001	**5**	0
canary	canario	**0.0034**	0	**15**	0	**3**	0
monkey	mono	**0.0033**	0	10	0.1207	**3**	0
centipedes	cienpiés	**0.0032**	0	**18**	0	**4**	0
cockroach	cucaracha	**0.0032**	0	**14.3333**	0	**3**	0
caterpillar	*xigala*	**0.003**	0	8.5	0.3321	**2**	0
farm turkey	pavo	**0.0028**	0	**14.25**	0	**4**	0
sparrow	gorrión	**0.0025**	0	**15.3333**	0	**3**	0
Coral snake	coralillo	**0.0024**	0	**11.6667**	0.0023	**3**	0
quail	codorniz	**0.0023**	0	9.5	0.2583	**2**	0
porcupine	puercoespín	**0.0023**	0	9	0.4613	**2**	0
insect	insecto	**0.0022**	0	**15.5**	0	**2**	0
beetle	escarabajo	**0.0021**	0	**18**	0	**2**	0
fierce	*tekuani*	**0.0021**	0	**11.25**	0.0066	**4**	0
caterpillar	oruga	**0.0019**	0	**17**	0	**3**	0
hare	liebre	**0.0017**	0	10	0.1207	**2**	0
cardinal bird	pájaro cardenal	**0.0017**	0	**6**	0.0003	**1**	0
grasshopper	saltamonte	**0.0016**	0	**7**	0.0138	**1**	0
palanca snake	palanca	**0.0015**	0	9	0.4613	**1**	0
mockingbird	zenzontle	**0.0015**	0	**15.5**	0	**2**	0
dragon fly	libelula	**0.0013**	0	**15.5**	0	**2**	0
jaguar	jaguar	**0.0012**	0	9	0.4613	**2**	0
horn pitviper	*nagascoatl*	**0.0012**	0	11	0.0135	**1**	0
aquatic snake	víbora de agua	**0.0012**	0	9	0.4613	**1**	0
axolotl	ajolote	**0.001**	0	**17.5**	0	**2**	0
parakeet	perico	**0.001**	0	**18**	0	**2**	0
hawk	halcón	**0.0008**	0	**16**	0	**1**	0
flea	pulga	**0.0008**	0	**20.3333**	0	**3**	0
chane	*chane*	**0.0005**	0	**23**	0	**2**	0
kinkajou	*biok*	**0.0004**	0	**15**	0	**1**	0

(Continued)

TABLE 2 | (Continued)

Item in English	Item in Spanish[a]	Salience (Smith Index)	Salience *p*-value	Mean position	Mean position *p*-value	Frequency	Frequency *p*-value
Stick worm	gusano de palo	**0.0004**	0	**23.5**	0	**2**	0
dove	pichón	**0.0004**	0	**22**	0	**1**	0
"capanila" bird	pájaro capanila	**0.0003**	0	**16**	0	**1**	0
dwarf	duende	**0.0002**	0	**24**	0	**2**	0
goose	ganso	**0.0002**	0	**27**	0	**1**	0
anteater	oso hormiguero	**0.0002**	0	**18**	0	**1**	0
moth	polilla	**0.0001**	0	**21**	0	**1**	0

Animal items listed: 108, Mean of Smith97 index: 0.069, Mean of Frequency: 46.20. Salient items and significative values ($p < 0.05$) are shown in bold letters.
[a]*Mexicatl names are instead provided for some animals (italics).*

TABLE 3 | Number of lists and items for each school group.

	High school Santa Maria	Secondary school Santa Maria	High school Ahuatla[b]	Secondary school Ahuatla[b]	Primary school Ahuatla	Secondary school Ixtlahuac	Primary school Caxalli	Schools Aticpac
Zone classification	Municipal seat[a]	Municipal seat[a]	Sierra Low	Sierra Low	Sierra Low	Sierra High	Sierra High	Tierra Caliente[c]
Number of lists	60	188	15	27	16	16	18	16
Total number of items	69	100	51	56	40	34	33	53
Number of salient items	17	23	11	10	10	7	4	11
Mean of Smith salience (lowest – higher value)	0.103 (0.001–0.669)	0.078 (0.000–0.611)	0.147 (0.003–0.623)	0.130 (0.001–0.568)	0.175 (0.002–0.555)	0.159 (0.006–0.757)	0.207 (0.012–0.558)	0.164 (0.003–0.695)
Mean of Frequency (lowest- higher value)	11.449 (1–55)	27.59 (1–156)	4.137 (1–14)	6.571 (1–21)	5.225 (1–12)	4.617 (1–14)	6.934 (1–11)	4.943 (1–14)

[a]*Including rural barrios Segunda sección and Cuarta sección;* [b]*selected from municipal head secondary and high school; and* [c]*10 students from elementary school, 3 from secondary school and 3 from the municipal head high school. Outputs available in Supplementary Additional File 2.*

the independent null hypothesis between a higher salience and damage reports for students (p-value < 0.05), but not for adults. A high percentage of the listed animals was not reported to have any use or did not cause any damage (**Table 5**).

Recognised Diet, Distribution, Seasonality, and Life Cycles

Diet

Most birds and mammals were reported to feed on sources related to anthropogenic activities such as crops, secondary vegetation, or domestic animals. However, trees identified as sources of food for birds and mammals in the lowlands of TC were black "*zapotl*" [*Diospyros nigra* (JF Gmel.) Perrier], "*amatl*" (*Ficus* sp.), and "*yoloxochitl*" (*Magnolia* sp.), while in the highlands, "*xometl*" (*Sambucus mexicana* C. Presl ex DC), pinecones (*Pinus* spp.), and acorns (*Quercus* spp.) were mentioned. White tailed deer was reported to feed on "*apashmama*" (*Lopezia racemosa* Cav.) and "*teterisia*" (*Monnina xalapensis* Kunth) leaves, butterflies, bees, stingless bees, hummingbirds, and bats were recognised as flower visitors that feed on nectar and pollen. On the other hand, bats were also identified as blood suckers, frugivorous, and insectivorous. Dogs and cats were reported to feed mainly on wild fauna and on human leftovers (**Supplementary Additional File 3**).

Environmental Units of Presence and Distribution of Fauna

We found similar trends across age groups in the identification of environmental units associated to presence and distribution of fauna. Three categories of distribution were identified: (1) general environmental units, including mount (the most frequent response in all age groups), field, water bodies, homes, and milpas standing among other crops such as banana, apple, peach, and pea; (2) specific elements of the environment, namely trees (the most frequent response in all age groups), stones, herbs, soil, under the stones, underground, dry trees, rotten trees, canyon, and trails, among others; and (3) spatial units, namely, TC and Tzintzintepetl Hill. TC was related to mammals, snakes, birds and arthropods. Tzintzintepetl Hill was related to wild animals in general and fantastic fauna (eg., an animal that produces gold). The main difference between generations was that spatial units were not reported by children from elementary schools, but were mentioned in workshops of secondary-high school and in interviews with adults (**Supplementary Additional File 6**).

TABLE 4 | Smith salience index, mean position, and frequency of wild animal items in 16 adults' free lists, with *p*-values.

Item in English	Item in Spanish[a]	Salience (Smith Index)	Salience *p*-value	Mean position	Mean position *p*-value	Frequency	Frequency *p*-value
squirrel	**ardilla**	**0.612**	0	3.8571	0.1551	**14**	0
deer	**venado**	**0.6048**	0	2.9167	0.0723	**12**	0
rabbit	**conejo**	**0.4575**	0	4.7273	0.2597	**11**	0
white nosed coati	**tejón**	**0.3952**	0.0001	2.875	0.0723	**8**	0.0064
racoon	**mapache**	**0.3665**	0.0005	5.3333	0.3332	**9**	0.0009
opossum	**tlacuache**	**0.2933**	0.0068	3.3333	0.1093	6	0.0853
armadillo	**armadillo**	**0.2617**	0.0195	6.7143	0.534	**7**	0.0274
snake	víbora	0.212	0.0716	6.875	0.4511	**8**	0.0064
peccary	jabalí	0.1629	0.2049	8.2	0.2839	5	0.2063
paca	tepezcuintle	0.136	0.3254	9.8333	0.1492	6	0.0853
skunk	zorrillo	0.1335	0.3386	5.5	0.3737	4	0.4103
dove	paloma	0.1251	0.3817	7	0.4511	5	0.2063
ring tailed cat	*chicna*	0.1056	0.4941	7.3333	0.3948	3	0.5897
gray fox	zorra	0.1027	0.4755	4	0.1982	2	0.3295
bird	pájaro	0.0997	0.456	6.5	0.5148	4	0.4103
quail	*koyotcho*	0.0943	0.4192	6	0.457	4	0.4103
bat	murciélago	0.0936	0.4132	5.5	0.3737	2	0.3295
wessel	onza	0.0786	0.3233	7.5	0.3777	2	0.3295
margay	tigrillo	0.0625	0.2323	8.5	0.2614	2	0.3295
scorpion	alacrán	0.0595	0.2015	4.5	0.2435	2	0.3295
rattlesnake	cascabel	0.0583	0.1951	9	0.2236	2	0.3295
coyote	coyote	0.0574	0.1891	9	0.2236	2	0.3295
hummingbird	colibrí	0.0529	0.1637	3	0.104	1	0.114
turtle	tortuga	0.0481	0.1397	4	0.1982	1	0.114
hawx	*kuixi*	0.0469	0.1338	5	0.3197	1	0.114
lizard	lagartija	0.0441	0.1198	11.6667	0.0657	3	0.5897
woodpecker	p carpintero	0.0439	0.1193	12.5	0.0482	2	0.3295
owl	tecolote	0.0404	0.1026	7	0.4511	1	0.114
frog	rana	0.0341	0.0798	11	0.0977	1	0.114
black widow	viuda negra	0.0312	0.0677	4	0.1982	1	0.114
anteater	oso hormiguero	0.0288	0.0607	8	0.3247	1	0.114
iguana	iguana	0.0284	0.0595	**13**	0.0416	1	0.114
mouse	ratón	0.0267	0.0534	**14.5**	0.0201	2	0.3295
mazahuatl snake	*mazahuatl*	0.0257	0.051	11	0.0977	1	0.114
kinkajou	*biok*	0.0256	0.0505	**14**	0.0257	1	0.114
pheasant	faisán	**0.0246**	0.0476	8.5	0.2614	2	0.3295
eagle	águila	**0.024**	0.0455	9	0.2236	1	0.114
coral snake	coralillo	**0.0221**	0.0421	12	0.0641	1	0.114
agouti	*kowtuza*	**0.0208**	0.0366	9	0.2236	1	0.114
tonalquetzi bird	*tonalquetzi*	**0.0192**	0.0316	10	0.1481	1	0.114
tepotzo snake	*tepotzo*	**0.0184**	0.0312	**13**	0.0416	1	0.114
ahuatl snake	*ahuatl*	**0.0147**	0.0223	**14**	0.0257	1	0.114
rat	rata	**0.0142**	0.02	**18**	0.0053	1	0.114
cricket	grillo	**0.0114**	0.0163	**19**	0.0039	1	0.114
gopher	tuza	**0.01**	0.0133	**12.5**	0.0482	2	0.329
cockroach	cucaracha	**0.0085**	0.0076	**20**	0.0028	1	0.114
Mexican alligator lizard	*kuwishi*	**0.0078**	0.0065	**15**	0.0182	1	0.114
fly	mosca	**0.0048**	0.0014	**13**	0.0416	1	0.114

Animal items listed: 48, Mean of Smith97 index: 0.109, Mean of Frequency: 3.167 Salient items and significative values ($p < 0.05$) are shown in bold letters.
[a]*Mexicatl names are instead provided for some animals (italics).*

TABLE 5 | Contingency tables with the count of items with use and damage reports included in free lists.

Group of freelists	Variable	Use (proportion in brackets)			Damage (proportion in brackets)		
Students	**Salience**	**no**	**yes**	**total**	**no**	**yes**	**total**
(108 items)	no	62 (0.57)	22 (0.20)	84 (0.77)	62 (0.57)	22 (0.20)	84 (0.77)
	yes	3 (0.02)	21 (0.19)	24 (0.22)	10 (0.09)	14 (0.12)	24 (0.21)
	Total	65 (0.59)	43 (0.39)	108	72 (0.66)	36 (0.32)	108
Adults	Salience	no	yes	total	no	yes	total
(48 items)	no	22 (0.45)	19 (0.39)	41 (0.85)	19 (0.39)	22 (0.45)	41 (0.85)
	yes	0	7 (0.15)	7 (0.15)	1 (0.02)	6 (0.13)	7 (0.15)
	Total	22 (0.45)	26 (0.54)	48	20 (0.42)	28 (0.58)	48

Insects (*Okuilitzin*)

"Hoja santa" or *"nextokuili"* (Coleoptera: Melolonthidae) (D27 TC) is an animal that becomes the plant "*tlanekpakilitl,*" *Piper auritum* Kunth, after it burrows underground (D20 TC, D21 TC, D23, TC). The similarity of the inflorescence of the plant to a white worm is interpreted by participants as a vestige of this transformation (D23 TC).

"*Kuetla*" is the immature stage of the butterfly *Arsenura armida* Cramer (**Figure 2**). Three instars were recognised. In the first one, caterpillars have "horns" and are small and dark. As they grow, they lose their horns and become fatty. When they are ready to be eaten, they are fatty, with green, orange, and dark stripes. They can be found in groups of over a hundred in the higher section of a single trunk of a *Heliocarpus appendiculatus* Turcz tree. They lay in the trunk during the day, but feed on leaves at night. People said that when *kuetlas* fall from trees, they are eaten by snakes. Therefore, people must be aware and mindful when approaching a *Heliocarpus* tree to collect *"kuetla."* Some women expressed their phobia towards these larvae. They are found in groups, which are called "little herds" or "*setlamoxotzintli*" in Mexicatl (Nahuatl) (D23 TC). *Kuetlas* availability occurs mainly in July but also on October.

A life cycle involving Hepialidae, Saturniidae, Cicacidae, and Melolonthidae was proposed in TC, where these insect groups co-occur. The "*chajkchama,*" "*chajchamokuili,*" or true *"poxokuili"* larvae (immature Hepialidae) live inside the "*chajkchamakowitl*" tree (*Lippia myriocephala* Schltdl. And Cham.) for 2 or 3 months. Since woodpeckers predate them, they are usually only found in the lower sections of trees (D43 TC). Then, the "*chajkchama*" enters a stage in which "it loses its hands" (corresponding to the pupa, called "*mosawa*"), and afterwards becomes a butterfly (**Figure 2**). Then, the butterfly will only live for around a month and lays its eggs in a different tree (*H. appendiculatus*). These eggs become the *poxokuili or "kuetla"* (immature stages of *A. armida*). Afterwards, these *kuetla* fall down, burrow in the soil, and become a cicadas (Cicacidae) "*xikilixi,*" which is seen aboveground for 3 or 4 months during the warm season. Some people have heard that this cycle further continues—that Cicacidae become "*nextokuili*" (Melolonthidae) and *Piper auritum*. It is because of such cycles of metamorphosis linking one insect to another that *Lippia myriocephala*'s bark and *Piper auritum* leaves and stems have nice, beautiful, and similar smells (D23 TC, D43 TC).

Reptiles

Snakes (kuwatl). In the Sierra region the main kind of snakes recognised by people were the rattlesnakes "*tehuankuwatl*" (*Crotalus* spp.), the aquatic snakes "*ahuatl*" (*Thamnophis* sp.), and the horned vipers "*akaskuwatl*" (*Ophryacus* spp.). According to locals, rattlesnakes are abundant and fearful. They run away or hide inside the earth in the presence of people. Therefore, snake bites are rare events. Snakes are often seen near fallen trees (D14

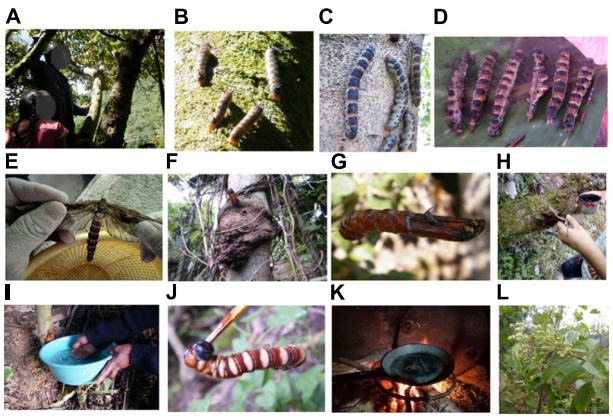

FIGURE 2 | *Kuetlas*, also called *poxokuili*, are collected from *H. appendiculatus* in the secondary vegetation and then relocated in a *H. appendiculatus* tree into the family home to be maintained under surveillance. **(A)** A girl and his grandfather supervise that a small group "manadita" recently collected climbs up the selected tree. At this stage, *kuetlas* had horns **(B)**, but the procedure can be also done with more mature *kuetlas* such as in **(C)**. **(D)** *Kuetlas* roasted by the girl's grand-grandmother are ready to be eaten as a snack. *Hepialidae gathering*. After identification as "the mother," an adult was released by a man in TC, with the intention of assuring the presence of this animal **(E)**. If the house or "little sponge" in host trees is intact, the worm must be present. Otherwise, the sponge will have holes or the molt left in the change from pupa to adult can be seen **(F,G)**. A girl in TC **(H)** and a woman in Sierra **(I)** show how to take out a "worm" from *Lippia myriocephala* and *Fraxinus* sp. **(J)** using water to drown it and, afterwards, using a spine to extract it when its head comes out. It must be done in silence since worms are very aware of the presence of predators. If they notice that a person is nearby, they will not come out. **(K)** Worms are fried with salt and eaten as a snack. **(L)** *L. myriocephala*.

S). Meanwhile, aquatic snakes are perceived to be abundant in rivers and springs, mainly during April and May (D11 S, D12 S). Their abundance in the Sierra is the reason why the village "Ahuatla" has its name (D8 S) (although "*ahuatl*" can also have other meanings such as "thorn" or "oak"). They are also fearful and do not bite. According to participants, they "just see you and jump into the water" (D12 S). In contrast, the horned pit vipers are considered to be fearless and wait for people or even approach closer instead of running away (D8 S, D12 S). However, encounters with this snake may have a symbolic value (D13 S). A man is said to have killed one, and to his surprise, inside the snake were nine smaller ones – its offspring. This meant that this kind of snake does not lay eggs, as locals have thought before "it is like a rabbit, not like a bird" (D8 S).

Because the offspring were different sizes, he thought that some of them were more mature than others and, therefore, were meant to born at different times (D8 S). The man wondered how many at a time and how often. Coral snakes, called "*eskuwatl,*" were also reported in the Sierra, but were more often associated to TC (D11 S), where there is a much higher abundance and variety of snakes are recognised. However, species richness in the Sierra was recognised to be underestimated as a participant said, "there are more snakes, but we do not know how to identify them because we do not know them" (D16 S). Lizards *"kuwishi"* (*Abronia* spp.) are believed to be "the mother of the rattlesnake" which may explain why they are considered as poisonous and even feared (D13 S).

Mammals

Small mammals like squirrels, rabbits, and opossums are commonly seen near villages or in crop fields. In the Sierra, two kinds of squirrels are recognised by people: one arboreal which has red hair "*chichilmoto*" (*Sciurus aureogaster* F.Cuvier) and one of the same sizes, but grey, that inhabits within holes in the rocks and is called "*tlalmoto.*" In TC, a third type, called "*tepaxi*" or "*tepaxitsi,*" which is smaller and feeds on nuts was recognised. Rabbits are commonly seen in the field (D10 S, D8 S). They are born within a hole in the ground, during which the female removes its hair and places them inside the hole to shelter her cubs. If she comes out, she covers the hole with ground to avoid predation by weasel (*Mustela frenata* Lichtenstein) (D8 S).

Opossums are active at night (D10 S) and the data gathered mainly came from people that had direct experiences killing these animals.

"Once we killed one, and after the sunrise its cubs were around the body, they were nine, without hair, the size of a new-born kitty [. . .] it carries them on its bag" (D11 S).

"my husband once found one of them with their cubs, he says it has a little hole in its belly, but it is not actually a hole, it is a little bag and there is where babies are. Why don't these babies fall? Well, I don't know, he says, they are just stuck in there" (D12:19 S).

Other animals are more frequently seen in forests and are seasonally associated to crop fields, such as racoons and skunks (D8 S, D23 TC). The racoon is reported to be associated with places full of trees (D 11 S) which it climbs (D 23 TC) and, similarly, to *Nasua narica* L. and *Pecari tacaju* L., it can be seen either alone (solitaries are called "*seltwa*") or in groups (called "*mieke*" or "*miektli*") (D23 TC). Also, it is recognised to store its food as a participant said, "My husband's uncle once told him that they went to find firewood and tried to pull a dry stick from a tree, and when they were pulling it, a lot of maize fell down, because inside, they store their food" (D18:66 S). Two kinds of skunks are recognised: the *cadena* skunk (bigger, with one big with spot in the back; *Mephitis macroura* Lichtenstein) and the *caparote* skunk (smaller, black with small white spots in the body; *Spilogale putorius* L.). They are nocturnal (D23 TC) and their presence is desirable in Sierra cornfields since they feed on Melolonthidae larvae that plague maize roots (D8 S).

Armadillo is easily recognised by its shield as a participant mentioned, "if you touch it, it gets inside and rolls" (D11 S), and because it leaves a trace of little holes in the soil (D11 S, D23 TC). It lives under the soil or rocks, and once it has burrowed into the soil, it is not possible to take it out even by pulling the tail (D12 S). They have been seen with 3 cubs (D23 TC).

Deer is the biggest mammal recognised as common in the area. Based on the shape and size of their antlers, different kinds of white tailed deers (*Odocoileus virginianus* Zimmerman) are recognised by people in the Sierra. The "*chilliwa*" has antlers shaped like a basket in accordance to its namesake, "*chiwi,*" means basket. It is smaller than the "*tlegalatzi,*" which is named after their resemblance to the shape of a wooden pole. There is also the "*xokotewitswa,*" which is a big deer, but with small antlers that end in a small sphere that resemble a "*tejocote*" (*Crataegus mexicana* DC) fruit (D8 S). However, the white tailed deers that have been recently seen near villages in the Sierra region have small antlers (D11). The size of the antlers is also the criterion used by some people, mainly the young, to differentiate males (bigger antlers) from females (D26 TC). "*Temotzi*" (*M. temama*) is distinguished as a small and reddish deer, which only lives in TC (D8 S, D22 TC). The loss of the antlers of the deer is recognised. However, there is no consensus on how often it happens. One man of the Sierra argued that "People say that the antlers fall down. They say every year, but I don't think so (. . .) they look really sturdy (...) they are never seen on the ground, where these fall, then? (. . .) Antlers fall, but maybe after 10 years" (D7:16 S). In contrast, a hunter in TC stated that all deers throw away their antlers every year on San Andrés Day (D43:3 TC), celebrated on November 30. The behaviour of brushing up the antlers against trees has been observed in November (D7 S), the mating around mid-November, and young deer, aged about 1 month, whose skin is covered with white spots are seen around June. Therefore, pregnancy is calculated to last about 6 months (D7 S). Deers were differentiated from other mammals because they lack vessel "*xixiwa*" (D8). They are known to make their own paths or use human paths to move across vegetation (D8 S, D20 TC).

Paca (*Cuniculus paca* L.) is nocturnal, and although it is not often seen by most people, its feeding sites are identified in TC because it leaves the peel of the fruits, such as lime or avocado. It has two frontal teeth, and cubs are born (1 or 2) between May and June. It burrows in the rocks and caves. While most people call it just "*tepezcuintle,*" one man distinguished two kinds. The

TABLE 6 | Trends in animal's abundance and their causes, as reported in adults' interviews.

Animal	Zone	Previous abundance (Before 35–50 years)	Trend in abundance (In the last 35–50 years)	Cause	Reference to sources	Number of persons that mentioned it
Insects						
Lepidoptera						
Giant silk worm "kuetlas"(*Arsenura armida*)	TC	nd	Decreased	ND	D27	1
Poxokuiles*(Arsenura polyodonta)*	Municipal seat	High	Decreased	Shifts in rain patterns	D43	2
Diptera						
Flies	Sierra	Low	Increased	Use of "gallinaza" as fertiliser[a]	D16	1
Birds						
Cuculidae						
Roadrunner(*Geococcyx velox*)	Sierra	Low	Disappeared	Hunting and dogs	D7	1
Phasianidae						
Creole chicken(*Gallus gallus*)	Sierra	High	Decreased	Arrival of chickens "from the city"	D11	1
Farm chicken(*Gallus gallus*)	Sierra	Low	Increased	Egg laying periodicity and fatten speed	D11	1
Mammals						
Didelphidae						
Opossum(*Didelphis* spp.)	Sierra	High	Decreased	Fire	D10	1
Dasypodidae						
Armadillo(*D. novemcinctus*)	Sierra	High	Decreased	Fire	D10, D16	2
Armadillo(*D. novemcinctus*)	TC	nd	Increased	Human consumption has decreased	D25	1
Canidae						
Coyote(*Canis latrans*)	Sierra	High	Dissapeared	Fire	D7, D11, D13, D15	4
Coyote(*Canis latrans*)	Sierra	High	Dissapeared	Hunting	D7	1
Felidae						
Tigrillo(*Leopardus* sp.)	TC	nd	Decreased	Hunting	D21	1
Leporidae						
Rabbit(*Sylvilagus* sp.)	Sierra	High	Decreased	Fire	D10, D11	2
Cervidae						
Deer(*O. virginianus*)	Sierra	High	Decreased	Fire and logging	D10, D11, D16	3
Deer(*M. temama*)	TC	nd	Decreased	Hunting	D25	1
Sciuridae						
Squirrel(*S. aureogaster*)	Sierra	High	Decreased	Fire	D10, D11	2
Squirrel(*S. aureogaster*)	TC	High	Decreased	ND	D19	1
Cuniculidae						
Paca(*C. paca*)	TC	High	ND	ND	D23	1
Animals in general	TC	High	Decreased	Fire	D27	1

[a] *"Gallinaza" is a poultry excreta-based fertiliser bought from the chicken farms established in Tehuacán. This fertiliser is considered by some of the interviewed persons as "soil contamination," and it is acknowledged that it creates dependency despite how it helps to increase crop productivity, at least in the short term. The adoption of this practice was facilitated after the temporal migration of men to work in agricultural fields in Tehuacán.*

bigger has big cheeks and is called "*tekomawa,*" while the smaller "*kowtetekiwsi*" has no cheeks (D23 TC).

Mammals that are not often seen are felids, namely, porcupine and kinkajou. Small felids identified in pictures as *Leopardus wiedii* Schinz are recognised as small beasts called "*tekuantsin*" which are common in TC, especially near the *Pinus* spp. forests where there are a lot of squirrels. However, it is not easy to find them because they avoid humans. Bigger felids, such as *Leopardus pardalis* L., are recognised as big beasts called "*wey tekuani.*" They are hunter animals but are locally scarce (D23 TC). Although the kinkajou is well recognised by its call, even mimicked by children (**Supplementary Additional File 4**), it is often identified in pictures as a monkey. Porcupines are recognised to spend all their life just lying on top of trees in TC, hypnotising small animals as mentioned by a participant, "It has a kind of magnet for attracting them, who knows how it does for putting these animals to sleep." Its reproduction data are unknown (D23 TC).

Causes of Fauna Extirpation

Hunting and fires in the limits of Coyomeapan and Zoquitlán were recognised as the main causes of fauna decrease and extirpation (**Table 6**). Great fires were dated before 1970 and between 1970 and 1990. The official fire record (Comision Nacional Forestal, CONAFOR, Puebla) shows a great fire in 1998 (at least 1,000 ha affected). During 2018, we

FIGURE 3 | Animals managed and used. **(A)** A captured rabbit (*Sylvilagus* sp.) is held in captivity in Sierra; **(B)** lambs are forced to use a bottle in their mouth to prevent conflicts caused by grazing in inappropriate places; **(C)** a duck grooms a puppy in Sierra. These birds are kept in homes to prevent illness in other domestic animals; **(D)** Chaparra, a specialised hunter dog in TC; **(E)** Turkeys are considered to be rude, but highly appreciated as edible and gifts in celebrations; **(F)** A meal with *Poxokuili* (*Arsenura polyodonta* Jordan) bought in the municipal head plaza prepared in "salsa" and a soup. These *poxokuili* are collected from *Ceiba* sp. tree in Chimalhuaca, a nearby village, and are annually available around August, depending on the rainfall. Men collect them and women prepare and sell them; **(G)** An armadillo carcase exhibited in TC, **(H)** *Sciurus aureogaster* skin exhibited in TC; **(I)** Furniture with *Mazama temama* legs as pieces; **(J)** *C. paca* skull kept in exhibition in a home in TC after being eaten; **(K)** bull horns exhibited in a home in Sierra, **(L)** *Didelphis* sp. hand kept as a souvenir in Sierra; **(M)** *Actias truncatipenis* (Sonthonnax, 1899) and other butterflies are kept as a souvenir in the Sierra; Some yellow butterflies are used by children as temporal tattoos; Toucan's bills are exhibited and used in traditional medicine in TC **(N,O)**; **(P)** Snakes that are perceived as poisonous are drowned and kept in sugarcane alcohol as part of the first-aid kit in homes in Sierra and TC; **(Q)** The dorsal gland of a peccary is kept in sugarcane alcohol to attend labour complications in TC; **(R)** While the outer part of immature Hepialidae are edible, the inside is used to treat herpes labialis; **(S)** Vespidae-*Leucaena* sp. galls are sold in municipal seat plaza as a snack. **(T)** *Arsenura polyodonta* are individually prepared with the quelite known as "*pipitza*" [*Porophyllum tagetoides* De Candolle (DC)].

observed the beginning of a 15-day long fire in the limits of Coyomeapan and Zoquitlán. According to people, this fire caused the burning of wild and domestic animals. Sharing of testimonies and pictures of these animal remains (testimonies D43) contribute to explain why fire is identified as a major factor that causes fauna extirpation. We observed that people living in communities closer to pine forest quickly responded in volunteer brigades to dig ditches and prevent the advance of fire.

Use Typology

Eighteen use categories were reported for domestic and wild fauna by students, and 13 of these were also reported by adults (**Table 1** and **Figures 3**, **4A**). **Table 7** includes data on consumption events along a year while **Table 8** includes data on local prices of traded fauna (frequencies of mention for each animal are available in the **Supplementary Additional File 3**). A specialised hunting dog can cost above 3,000 Mexican pesos. Since it is considered hard to find, in case of non-solved conflicts, killing dogs that belong to another hunter is a local form of revenge.

Between the Sierra and TC, we found redundancy in the presence of most animals. However, use reports differed between Sierra and TC. This was the case of the medicinal use of opossum "*tlakua*" (*Didelphis* spp.) to induce labour in Sierra (D10 S, D11 S, D12 S) instead of porcupine "*wistlakua,*" meaning literally opossum with thorns (*Sphiggurus* sp.) (D23 TC), the dorsal gland of peccary (D21 TC), and the penis of *M. temama* (D43) which are used in TC.

Preference Information

Among edible animals, preferences and selection for a particular phenotype or species are trade-offs between size, taste, smell, colour, behaviour, quality of meat, fattening speed, and, in the case of birds, egg laying reliability. It is desirable to own both sexes of a domestic animal, otherwise, people must borrow stallion from neighbours (10 S). Fattening speed overcomes colour of turkeys (D10 S, D14 S). Taste of creole hens is preferred over taste of farm hens brought from the city, but the latter fatten faster than creoles and are reliable laying hens whose white eggs can be easily sold (D11 S). In general, hen eggs overcome turkey eggs as edible. However, turkey eggs are preferred for healing in "limpias" (D10 S), a ritual performed to prevent, diagnose, or heal several illnesses.

Animal behaviour also determines preferences. Turkeys, for instance, peck people, escape very often (D18S, D19S), get ill easier, and require more care for being fed compared to other poultry (D10 S, D13 S, D18 S, D41). However, female turkeys are excellent hatchers for eggs of both hen and turkey (D10 S). Moreover, both male and female turkey are important as a gift to the godparents in social celebrations such as weddings or in the anniversary of someone's death (D6 S, D41). Regarding smell, lamb meat is preferred over the goat meat because the latter is considered to smell badly (D41). Meats of rabbit and squirrel are preferred over that of racoon, since the latter has a smell called "*xoquilla,*" like a raw egg (D25 TC).

Paca stands among wild animals as a special food. People considered it as "freaking awesome" (D23:66 TC), sacred, a special gift to someone (D41), an animal that is killed because

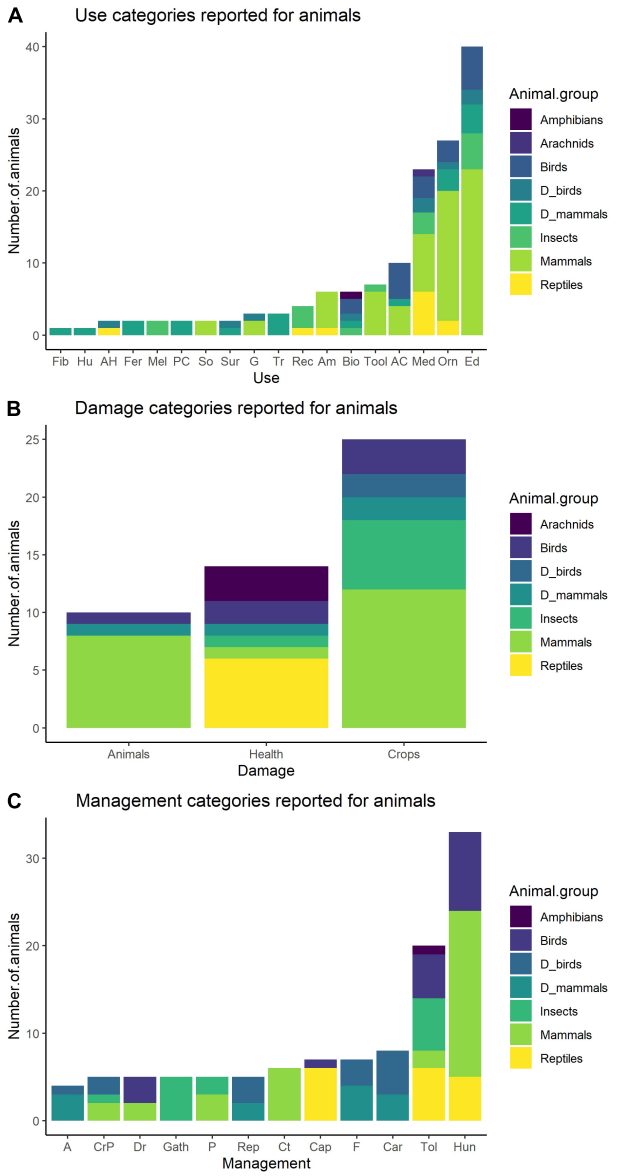

FIGURE 4 | Distribution of use, conflict, and management categories for animal group. **(A)** Use categories: Edible (Ed), Ornamental/exhibition (Orn), and Medicinal (Med) categories. Those with more reports were mainly represented by wild animal items. However, seven categories were only reported for domestic animals. AC, animal companion; Bio, bioindicator; Am, amulet; Rec, recreational; Tr, traction/transport; G, gift/offering; Sur, surveillance; So, souvenir; PC, pest control; Mel, honey production; Fer, fertiliser; AH, animal health; Hu, aid in hunting; Fib, Fibers. **(B)** Damage categories: both wild and domestic animals were related to damage. **(C)** Management categories. Tol, Tolerance; P, poison; CrP, crop protection; Gath, gathering; Cap, capture (obtaining snakes and birds, but not killing them to get them); Ct, captivity (keeping the animal alive at home); Hun, hunting; Dr, drive away; Rep, reproduction; Car, cares; F, feeding; A, agreements. Elaborated in R software (Rudis et al., 2020; Garnier et al., 2021; Wickham et al., 2021).

it is a delicacy (D20 TC), and has healthy meat, available throughout the year (D23 TC). It lives in TC, but is also consumed in the Sierra as a memorable event (D12 S, D16 S). Nevertheless, a few people said they preferred the taste of other bushmeat. Deer, squirrel, white-nosed coati, armadillo, and the quail "*koyotcho*" are among the considered tastier animals (D10 S, D11 S, D16 S, D19 TC, D20 TC, D21 TC, D24 TC, D25 TC, D26 TC, D27 TC).

An animal's diet also shapes people's preferences on its meat. *M. temama* meat is considered tasty and fresh because this animal "has a fine diet, based in wild fruits and plants from the *acahual*" (secondary vegetation). In contrast, the white-tailed deer is considered drier because it "feeds on dry leaves from the highlands" (D43). Similarly, some people perceive that eating armadillo is dangerous because they think these animals feed on coral snakes (D11 S, D20 TC).

People's age can influence food preferences. Most adults prefer the taste of the edible immature stages of *A. armida "kuetla"* compared to the "*chajkchama*" (Hepialidae), although the latter is more appreciated by children (D21 TC, D22 TC, D25 TC). The fact that these Hepialidae can be found at low height in the trees makes them easily accessible to be gathered by children, in contrast to other kinds of Lepidoptera in the area. Adults think that young people have experimented on changes in their preferences due to migration processes. For example, they do not like dotted eggs because of the colour (D10 S), or have abandoned local, healthy food that people used to eat more often in the past, including greens "*quilitl*" and bushmeat (D10 S).

Typology of Damages

The four kinds of damages caused by 36 animals (41 mentions) were damage to crops, predation of domestic animals, damage to human health, and damage to merchandise (**Table 1** and **Figure 4B**) (Frequency available in **Supplementary Additional File 3**).

We identified differences in animals recognised as damaging between the Sierra and TC. This results in different attitudes towards the animal and the decisions to eliminate it in one region, but to accept it in other. For example, the Coleoptera larvae, known as "*xahuistli*" or *"nextokuili,"* are not appreciated in the Sierra since they feed on maize root. Therefore, crop rotation should be practiced. Otherwise, the milpa will be plagued (D8:14,15,17 S). Differently, in TC these larvae are appreciated because they are considered related to the life cycle of a valued green: *Piper auritum* (D20:103 TC, D21:81 TC, D27:30 TC, D43:8).

Participants said that the location of milpas influences the magnitude of damage that animals can cause. For instance, in TC, people that have their milpas high and close to the mount (mature vegetation) are those more affected by white-nosed coati and peccary (D26 TC, D27 TC).

Regarding snake bites, TC snakes were in general recognised as more dangerous than those in the Sierra and bites were reported to occur in first place on feet and in second place on people's hands, while working in the field or gathering firewood (D8 S, D12 S, D13 S, D14 S, D21 TC, D25 TC). In the case of Elapidae, the consequence is that "blood comes out from every pore in the body" and in just one case a man lost part of his hand, even after attention in the hospital (D8 S, D13 S, D25 TC). In the case of horned pit vipers, the consequence is swelling and deep

TABLE 7 | Consumption events and accessibility reported for edible animals in adult interviews.

Animal	Consumption events in a year	Zone	Number of adult informants	Reference	Accessibility	Reference
Insects						
Hymenoptera, Apidae						
Stingless bee honey (Meliponini)	<1	TC	1	D20	Hard to get.	D20
Lepidoptera, Saturniidae						
Kuetlas (*Arsenura armida*)	seasonally (July, October)	TC	2	D21, D26	Trade-offs: located near, but hard to find and climbing or tools are needed.	D20, D25
Lepidoptera, Hepialidae						
Chajchama (Hepialidae)	Mainly seasonally (February-March)	TC	1	D27	Trade-offs: easy to get, scarce during most of the year.	D21, D25
Birds						
Tinamidae						
Quail (*Crypturellus* sp.)	1 (during bean season)	TC	2	D20, D26	Easy to get.	D20
Phasianidae						
Chicken meat (*Gallus gallus*)	6	TC	1	D19	NA	
Turkey meat (*Meleagris gallopavo*)	Celebrations	TC	1	D20	Hard to raise.	
Turkey meat (*Meleagris gallopavo*)	Celebrations	S	1	D6	Hard to raise.	D18, D19, D10, D13, D18
Mammals						
Didelphidae						
Opossum (*Didelphis* sp.)	6	S	1	D18	NA	
Opossum (*Didelphis* sp.)	<1	S	1	D16		
Dasypodidae						
Armadillo (*Dasypus novemcinctus*)	1	S	1	D12	Hard to get.	D12
Armadillo (*Dasypus novemcinctus*)	<1	S	1	D16		
Leporidae						
Rabbit (*Sylvilagus* sp.)	<1	S	1	D16	Easy to get.	D12
Procyonidae						
White nosed coati (*Nasua narica*)	1–2 (during milpa season)	TC	2	D24, D26	NA	
White nosed coati (*Nasua narica*)	3 (during milpa season)	TC	1	D19		
Racoon(*Procyon lotor*)	3 (during milpa season)	TC	1	D20	NA	
Racoon(*Procyon lotor*)	<1	S	1	D16		
Cervidae						
Deer(*Mazama temama*)	1–2	TC	3	D24, D20, D26	The most difficult to get, "about 150 individuals present."	D26, D23
Tayassuidae						
Pecary(*Pecari tajacu*)	1–2	TC	3	D19, D23, D26		
Sciuridae						
Squirrel(*Sciurus aureogaster*)	30 (during milpa season)	TC	1	D22	The most easy to get.	D26
Squirrel(*S. aureogaster*)	1–3	TC	3	D19, D24, D26		
Squirrel(*S. aureogaster*)	1	S	1	D11	Hard to get.	D11
Squirrel(*S. aureogaster*)	<1	S	1	D16		
Geomyidae						
Gopher (*Orthogeomys* sp.)	<1	TC	1	D23	NA	
Erizonthidae						
Porcupine (*Spigghurus mexicanus*)	<1	TC	1	D23	NA	D23
Cuniculidae						
Paca(*Cuniculus paca*)	4–15 (individuals killed)	TC	1	D23	Trade-offs: Plenty of individuals and always available but far from town	D23, D20
Paca(*C. paca*)	1–2	TC	2	D19, D20		
Paca(*C. paca*)	<1	S	2	D16, D12		

This information comes from semi-structured interviews, but does not come from a survey with statistical validity.

TABLE 8 | Price of animals locally sold.

Taxonomic identity	Sell unity	Rank of price in Mexican pesos	Perceived price	Reference	Number of adult informants	Price in USD for 1 kg
Insects						
Hymenoptera, Vespidae						
Polonxocos (Vespidae-*Leucaena* guts)	150 gr	5		D43 municipal head plaza	3	1.65
Lepidoptera, Saturniidae						
Poxokuiles (Arsenura polyodonta)	10 individuals (prepared)	10–20	Expensive	D43 municipal head plaza, D12 S	3	5–10
Kuetlas(Arsenura armida)	10 individuals (prepared)	10–15	Expensive	D21 TC, D20 TC, D25 TC	3	5–8
Reptiles						
Snakes (Ophidia)	sugar cane glass	20		D11 S		–
Birds						
Phasianidae						
Hen *(Gallus gallus)*	individual (alive)	100–150		D41 municipal head (May 23, 2019), D15 S		–
Creole hen *(Gallus gallus)*	piece	2.50–3		D16 S, D18 S	2	2.5
Male creole turkey *(Meleagris gallopavo*)	individual (alive) (5–8 kg)	500–800	Expensive	D41 municipal head (February 13, 2019; May 23, 2019), D18 S, D25 TC	2	–
Female creole turkey*(Meleagris gallopavo)*	individual (alive) (3.5 kg)	200–300		D11 S, D12 S	2	–
Male and female creole turkey *(Meleagris gallopavo*)	kg	80–100		D41 municipal head (May 23, 2019), D11 S, D12 S, D15 S, D18 S, D25 TC	5	4–5
Juvenile farm turkey*(Meleagris gallopavo)*	individual (alive)	35		D12 S	1	–
Mammals						
Didelphidae						
Opossum *(Didelphis* spp.)	tail	10		D12 S	1	–
Leporidae						
Rabbit*(Sylvilagus* sp.)	1/2 kg (prepared)	150	Expensive	D16 S	1	15
Mephitidae						
Skunk (ND)	individual	2000–10000	Expensive	D41 municipal head (February 15, 2019), D23 TC	1	–
Procyonidae						
White nosed coati*(Nasua narica)*	kg	60		D19 TC	1	3
Cervidae						
Deer*(Mazama temama)*	kg	70		D26 TC	1	3.51
Equidae						
Horse*(Equus caballus)*	individual (alive)	>7000	Expensive	D41 municipal head (May 28, 2019)		–
Donkey*(Equus asinus)*	individual (alive)	9000	Expensive	D41 municipal head (May 23, 2019)		–
Bovidae						
Lamb*(Ovis aries)*	individual (alive) (15–40 kg)	800–2000		D12 S, D15 S	2	2.5
Lamb*(Ovis aries)*	kg (alive)	50		D15 S, D16 S, D18 S	3	2.5
Goat*(Capra hircus)*	kg	50		D12 S	1	2.5
Tayassuidae						
Peccary*(Pecari tajacu)*	kg	80		D41 municipal head (February 15, 2019)		4
Sciuridae						
Squirrel*(Sciurus aureogaster)*	individual	15		D19 TC	1	1.65
Cuniculidae						
Paca*(Cuniculus paca)*	kg	80–500	Expensive	D41 municipal head (February 15, 2019), D19 TC, D21 TC, D23 TC	3	4–25

This information comes from semi-structured interviews, does not come from a survey with statistical validity.

pain, and in the case of *Crotalus* spp. sometimes even nothing (D8 S). To attend snake bites, it is considered enough drinking a "medicine" prepared with snakes and sugarcane alcohol, but a few people have also visited the clinic (D8 S, D12 S, D13 S, D14 S, D21 TC, D25 TC).

Fauna Management Typology and General Scheme

Definitions of each management category is provided below, indicating the theoretical category they belong to **Table 1** and **Figure 4C**, the fieldwork sources from which they emerged (interviews, workshops, field diary), examples, and, in some cases, further information about the interactions with other categories. Based on these interactions, we have proposed a descriptive scheme of fauna management (**Figure 5**):

Hunting

Definition: Vertebrates' extraction in a planned or opportunistic way using weapons, traps or, dogs. *Category:* Supply and extractive prevention. *Sources:* 16 adult informants: D7 S, D8 S, D9 S, D10 S, D11 S, D12 S, D13 S, D16 S, D18 S, D19 TC, D20 TC, D21 TC, D23 TC, D24 TC, D25 TC, D26 TC; school groups: D41, D42, field diary (testimonies) D43. *Examples for supply:* Fire guns, sticks or machetes are used to obtain medium sized mammals such as armadillo (D12 S, D16 S). Small birds are usually killed with slingshots (D16 S) but big sized birds that walk such as quails used to be obtained with a snare (D8 S) and more recently, with rifles (D20 TC). Gophers, rabbits and white-nosed coatis can be also obtained through traps. Dogs are involved in the hunt of deer, rabbit, armadillo and racoon but not in the hunting of paca or skunk. *Examples for extractive prevention:* Snakes (D12 S) and *kuwishi* (*Abronia* sp.) because they are considered poisonous. *Tekolotl* and *xiastli* (owls) because they are considered bad or witches. To prevent damage to domestic animals, people kill *tlakua* (opossum) which is considered "a bad animal, although its tail is good" (D11 S), or the coyote which is considered by most people to be extirpated. In the case of *tlalmoto* (squirrel), burrows are set in fire. Extraction of animals is also mediated through cats for rodent control, preventing predation on stored maize seeds. *Interactions with other categories:* Hunting strategies vary according to the animal natural history. For example, in TC, it is known that *temazate* deer feeds on the leaves of chili "*chiltepetl*" and follows paths in vegetation. Therefore, the hunter can wait for him. Other animals, such as white nosed coati or peccary, are waited in the milpas and hunted when they come to feed, especially in the maize season around October. Differently, the paca must be waited at night close to its feeding place, and a site to spy is built high in the trees, so the hunter can avoid been detected. Snakes are captured manually and kept alive until they are used to prepare an antivenom with sugarcane alcohol. However, they may be killed soon.

Wild Fauna Captivity

Definition: To control the feeding and mobility of an animal *ex situ*. *Category:* Supply. *Sources:* 11 adult informants: D5 S, D7 S, D8 S, D11 S, D12 S, D14 S, D16 S, D20 TC, D23 TC, D25 TC, D27 TC; school groups: D41, D42; field diary: D43. *Examples:* The animals kept in captivity for at least a year were rabbits (direct observation D43) and squirrels. Other animals which are brought to homes and die soon include agouti (*Dasyprocta* sp.), peccary and *temazate* deer (*M. temama*). Interviewed people identified the feeding as the main factor to captivity success. *Interactions with other categories:* The animal will die unless its diet is well known, or if it accepts a diet based on maize without getting ill, finding by itself part of its own food. In the case of peccary, their sharp teeth were the reason of deciding not continuing with captivity. Reproduction in captivity of wild fauna was not documented.

Gathering

Definition: Taking small animals through manual collecting or by tools, sometimes manipulating biotic elements such as host plants. *Category:* Supply. *Sources:* 8 adult informants: D12 S, D15 S, D20 TC, D21 TC, D22 TC, D25 TC, D26 TC, D27 TC; school groups: D41; field diary: D43. *Examples:* Gathering was documented for immature stages of lepidoptera (direct observation D43). In TC and in Sierra, people tolerate host trees (D27 TC) of immature stages of Hepialidae (*Lippia myriocephala* in TC or *Fraxinus* sp. in Sierra) to keep availability of these animals, which are extracted, mainly by children, using water and a spine. In TC, the immature stages of *A. armida*, called "*kuetlas,*" are collected from *jonote* (*H. appendiculatus*) trees by adults, mainly men, who use a bamboo stick from ground level, climb, or even log the tree to take the *"kuetlas"* more easily. Some people collect them from trees growing in secondary vegetation and then take them to their homes to keep them in a selected *H. appendiculatus* tree until they are ready to be eaten. This relocation requires an active surveillance of the animals to assure that they are eating well, they are safe from predators, and no other people is removing them. Stingless bee honeycombs are also collected. This implies the use of smoke or soapy water to drive bees away (D41). *Interactions with other categories:* see Agreements.

Feeding of Domestic Animals

Definition: People's choices on the kinds and sources of food offered to an animal, including choices on grazing land. *Category:* Supply. *Sources:* 14 adult informants: D8 S, D10 S, D11 S, D12 S, D14 S, D15 S, D18 S, D19 TC, D20 TC, D21 TC, D22 TC, D24 TC, D25 TC, D27 TC; school groups: D41. *Examples:* Almost all domestic animals are fed on maize grain or tortillas. However, turkeys feed on nixtamal (maize cooked in limewater) and as juveniles, the nixtamal should be enriched with *quelites* (*Cucurbita ficifolia* Bouché or "chilacayota" leaves, among others) (D10 S, D11 S, D18 S). Women sing to the juvenile turkeys (direct observation D43, audio examples available in **Supplementary Additional File 4**) and feed them in their mouth to make them easier to eat. In contrast, chickens that come from farms must be fed with commercial food until they get used to maize. Dogs and cats hunt small wild animals by themselves. Dogs are also fed with leftovers, duck eggs, or leftovers of killed animals as gophers. People maintain lambs, goats, horses, and donkeys locked at night and take them to graze the whole day. *Interactions with other categories:* A person who owns land takes his/her animals to

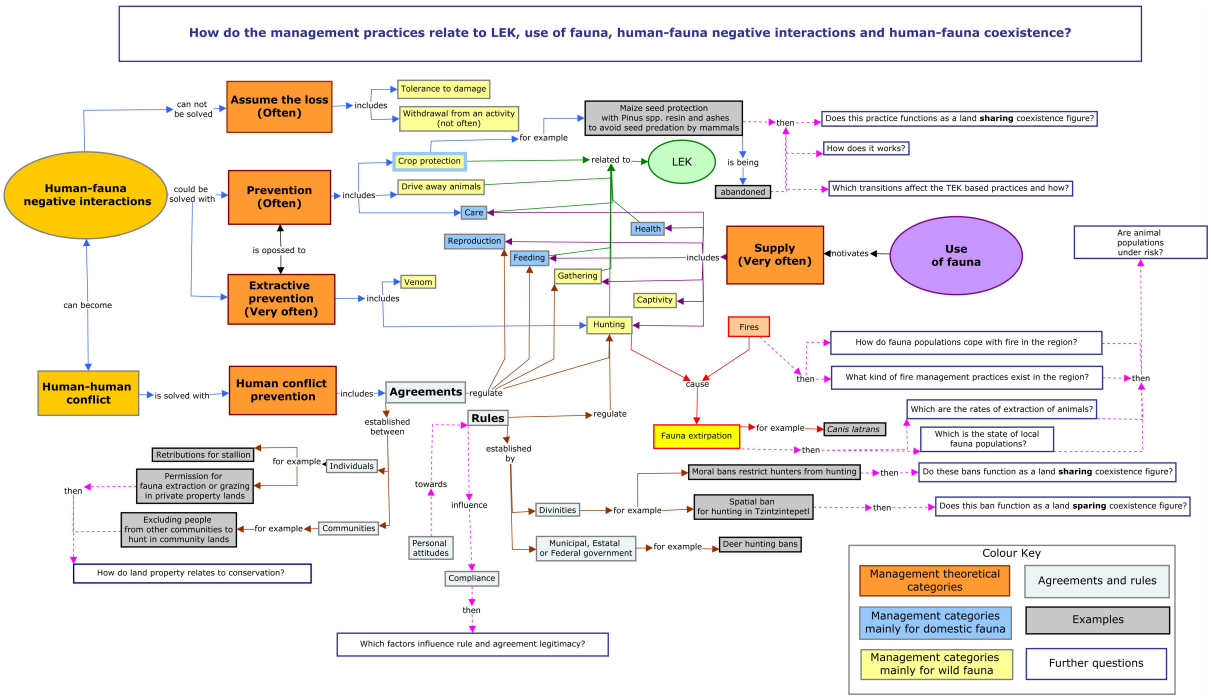

FIGURE 5 | General management scheme linking categories, examples, and further questions. Five management categories are shown. In the left side are those that respond to management of negative interactions between humans and fauna and human-human conflicts: assume the loss, prevention, extractive prevention, and human conflict prevention. The right side shows the supply which is motivated by the use of animals. Each of these five management categories include substantive categories which are non-exclusive. Yellow boxes show categories mainly related to wild fauna, while blue boxes show categories related mainly to domestic fauna. Crop protection contains both colours since it is related to both wild and domestic fauna. In the centre of the figure, local ecological knowledge (LEK) is related to several management practices for the prevention of damages to supply. Agreements are set to prevent human conflicts related to fauna supply decisions such as wild fauna extraction and domestic fauna reproduction. Rules also regulate hunting. Hunting and fires (orange boxes) have been recognised by interviewed persons as the main causes of fauna extirpation. Examples and further questions that arose in the process are included. This figure was elaborated with Cmap (https://cmap.ihmc.us/). A simplified version of this figure is available in **Supplementary Additional File 5**.

graze there, but others must have personal agreements with the landowners, or take the animals to graze to the mount.

Health of Domestic Animals

Definition: Animal illnesses recognised by people and their treatments. *Category:* Supply. *Sources:* 12 adult informants: D10 S, D11 S, D12 S, D14 S, D15 S, D16 S, D18 S, D21 TC, D22 TC, D24 TC, D25 TC, D26 TC; school groups: D41, D42; field diary D43. *Examples:* When they become ill, chickens and turkeys are fed with tomatoes or aloe (direct observation D43) and their underwing is smeared with tomato or sugarcane alcohol. To treat snake bites, horses are smeared with snake sugarcane alcohol and, in cases of birth complications, people provide an infusion of opossum tail. Prevention practices include vaccines and keeping ducks in homes to protect poultry and turkeys from getting ill. People place red threads to juvenile turkeys, lambs, and goats (direct observation D43) to avoid the "envy" (damage or illness caused by someone's negative emotions). The interest in finding the way to keep the domestic animals healthy is reflected in the experimental incorporation of information coming from different sources, including products announced in TV such as human antihistaminic pills, but also in the will of the people of participating in this research and interchange information with others about how to take care of their animals (D11 S).

Reproduction of Domestic Animals

Definition: People choices on sexual partners for animals, artificial selection criteria and care to ensure offspring survival. *Category:* Supply. *Sources:* 7 adult informants: D6 S, D10 S, D11 S, D12 S, D13 S, D14 S, D15 S; school groups: D41, D42. *Examples:* In turkeys, artificial selection does not seem to be rigorous. Females are cross breed with the male that is available, either because a friend lent it or because the female escaped to find a male by herself. If there were several available males, people would let the female choose, or would allow the fastest male to fertilise her. Some people invest great effort to grow the new-born turkeys. For example, by putting them inside a box with electric bulbs to maintain the heat, while others just cover them at night with a cloth, so the strong ones will survive (D10 S). In the case of hens, besides the meat, an element of selection are eggs. Women select from a hen the eggs of their preference (white, red, or yellow) and give them to another hen to hatch them, so they maintain a variety that will be for direct consumption or to sell. *Interaction with other categories:* see Agreements.

Cares Towards Domestic Animals

Definition: Protection of animals for their wellbeing, from escape, predation by wild fauna or exclusion from crops. *Category:* Supply and damage prevention. *Sources:* 8 adult informants: D10 S, D11 S, D13 S, D14 S, D16 S, D18 S, D19 TC, D21 TC; school groups: D41; field diary D43. *Examples for supply:* Women must be aware of turkeys (even chase them to bring them back) since they often escape. If the eggs of the hens locked inside the yard are fragile, sand is introduced so the hens can eat the small stones (D 41). The lambs must be sheared so they can be comfortable in the heat season even though their wool is not used or sold anymore. Their tails are cut when they are cubs, so they will grow more and will not get dirty. In the case of the few bulls in the localities, it must be avoided to take them to the mount because their legs broke easily and must be watched to avoid robbery from outsiders (D42). *Examples for damage prevention:* Often, locking the domestic animals within a cage or yard is enough to avoid predation by wild fauna, however, there is a trade-off between having them locked and their health since they "become sad" (meaning they get weak or ill). Consequently, they are maintained for great part of the day as free rangers. People try to keep the yard close to their homes since reducing this distance also reduces losses by predation. On the other hand, cages are also useful to avoid the chickens and turkeys to take out the plants that have been recently sown.

Drive Away

Definition: Scaring animals with noise or visual clues. *Category:* Damage prevention. *Sources:* 9 adult informants: D8 S, D11 S, D12 S, D13 S, D18 S, D20 TC, D22 TC, D25 TC, D27 TC; school groups: D41, D42. *Examples:* To avoid predation, the dog is locked within the cage or yard together with the chickens and turkeys. Since electric light arrived at the region ca. 15 years ago, the events of hematophagous bats feeding on domestic animals have decreased, therefore people place electric bulbs in the yards. This practice also dissuades the "*k'zoma*" (*Mustela frenata*) to get close. If the hens or turkeys cry, a prey bird must be close, so people scare the juvenile chickens with noises, so they hide to protect themselves. In TC, leaves of malango or *"awewejcho"* (*Colocasia esculenta* (L.) Schott) are put inside the gopher's burrows to cause irritation, so they will go away. To drive away the animals from crop fields, visual signs are used, especially scarecrows, constructed with cloths, or pieces of plastic.

Crop Protection

Definition: Direct protection of crops from animal predation with local technology. *Category:* Damage prevention. *Sources:* 3 adult informants; D13 S, D20 TC, D26 TC; school groups: D41; field diary D43. *Examples:* Put ash or lamb excreta around plants to drive away the gopher (D41). Corn seeds are protected from mammal seed predation, with ash and *Pinus* sp. resin (direct observation D43). This preparation implies the extraction of *Pinus* sp. chips and two *Agave americana* L. leaves, as well as the use of small dry branches enough to maintain a small fire for 1 h (**Figure 6**). *Interaction with other categories:* This practice is much less common than it was thirty years ago, and in words of one woman "we do not even know why it has been abandoned" (D43). Knowledge about how to perform this technique is transmitted from generation to generation as part of the wisdom inherited from the ancestors.

Poison

Definition: Commercial products that cause the death of animals and are applied in their food. *Category:* Extractive prevention. *Sources:* 3 adult informants: D12 S, D16 S, D25 TC; school groups: D41, D42. *Examples:* In the case of "*mapachi*" (racoon), poison is placed directly in corn; for the squirrel, it is placed in an avocado that is introduced in its burrow; for the gopher, the poison is mixed with corn dough and small balls of this mixture is placed in the seeding fields. Poisons are sold in the community, but their provenance is unknown.

Tolerance

Definition: People assume the damage because there is nothing that can be done. *Category:* Assume the loss. *Sources:* 3 adult informants; D8 S, D12 S, D13 S. *Examples:* This is the case of birds that eat the crops, after learning that the drive away strategies are not a threat. It is also the case of encounters with snakes (D13 S).

Abandonment of an Activity

Definition: Stop performing an economic activity because of the damages caused by fauna. *Category:* Assume the loss. *Sources:* One adult informant: D11 S. *Examples:* This was the case in which *Bassariscus* sp. fed on the eggs that were to be sold at a grocery store, so the owner gave up after several tries and stopped to sell the eggs because she had another source of income.

Agreements

Definition: Negotiations among people intended to prevent or reduce problems. *Category:* Human conflict prevention, conservation. *Sources:* 6 adult informants: D5 S, D8 S, D9 S, D13 S, D18 S, D21 TC, D25 TC; school groups: D41, D42; field diary testimonies and direct observation D43. *Examples and interactions with other categories:* These are mainly related to human conflicts involved in hunting, gathering, grazing and domestic animal reproduction. For conservation, agreements can involve land ordering and closure for preservation in the form of a legend, such as the recognition of the Tzintzintepetl Hill as a kind of fauna source, a place of great abundance of animals in which it is prohibited to hunt, otherwise the hunter would attract bad luck (D5 S, D41). Outside this area, agreements for regulating the access to resources in communal lands, i.e., any agreement of closure (calendar, age, sex) towards deer or other animals, were not registered. However, according to the customs, people do not go hunting in communities where they do not belong, and they do not accept hunters from other communities. Strong penalisation is applied to whom violate the rule (D8 S, D9 S).

There seems to be no regulation of the extraction of edible Lepidoptera in communal lands. However, there are personal agreements with private landowners to extract them (D21 TC, D25 TC). We did not register restrictions to grazing animals in communal lands, but action is taken to keep them from causing damage (D18 S). For lambs, they make masks with plastic bottles, or maintain them tied. For horses, their owner asks permit from a landowner before tying the horse in his

FIGURE 6 | Prevention of corn seed predation by mammals. **(A)** *Pinus* sp. Chips are extracted (ca. 1 kg) and placed in a clay pot. A clay molcajete is also shown (left). **(B)** The clay molcajete is placed in a hole below the earth and covered with two *Agave americana* leaves with a hole in the middle. **(C)** The chips inside the pot are placed on the top and sealed to the *A. americana* leaves with fresh clay. **(D)** The system is covered with branches and a fire is kept alive for 1 h before the sunset. After extinguishing the fire, the system is left to work all night. **(E)** The next morning, the resin can be collected from the molcajete. **(F,G)** The resins and ashes are spread over the seeds and mixed. **(H)** the seeds are ready to be sown or stored.

property (direct observation D43). If an animal causes damage, its owner must pay it.

In the case of animal reproduction, a personal agreement is taken to retribute the person who lent the male. In the case of turkeys, the retribution can be one new-born turkey; in the case of pigs, a symbolic economic retribution is well received (D13 S, D41, D42).

Rules

Definition: Regulations imposed from the outside, such as the federal, state, municipal, local or religious authorities. *Category:* Conservation. *Sources:* 5 adult informants: D5 S, D7 S, D9 S, D43 TC; school groups D41; field diary (testimonies) D43. *Examples and interactions with other categories:* According to people, a rule has been established by the municipal authority 12–15 years ago, forbidding deer hunting (D9 S), but deer hunting is practiced. Another recognised rule is the national army's request to register the possession of fire guns of any kind (D5 S). To reduce potential misunderstandings with military authorities, some people registered their guns and follow their hunting activity as usual, but others were dissuaded to hunt or are discrete about it (D7 S, D43).

Hunters recognised the need to ask for permission to divine authorities, specifically to San Andrés, before going hunting to the mount (D43 TC). Also, to avoid the "mal aire" (the illness caused by a damaging wind or spirit, that penetrates into the body of a person or an animal), a hunter must pray and ask permit to the owners of the animals. They also need to be aware of the signs they send to inform him on whether it is possible to go hunting. In addition, the hunter should not bring any money, otherwise animals will not appear (D43 TC). However, extraction of small birds and mammals with a slingshot, performed mainly by children and with edible purposes, seems to have open access (D41).

Attitudes

Definition: Personal ways of feeling or thinking about a situation (related to management practices), including a rule or an agreement, and which may reflect a behaviour. *Category:* Conservation. *Sources:* 4 adult informants: D7 S, D10 S, D11 S, D23 TC; field diary (testimonies and direct observation) D43. *Examples:* We observed that adults of Hepialidae moths were identified, and people took care of them to assure the following year there would be enough "worms" (direct observation D43, July 2019). Several people had personal regards towards avoiding the unregulated logging and mistreating animals, they expect that with these actions the forest will remain alive, and the water cycles will remain functional (D10 S, D11 S). The respect to rules and agreements may be also a question of attitude (D7 S, D23 TC, D43). Something similar happens with the act of killing animals associated to bad luck like owls or foxes: some people fear that if they kill the animal, they will also die, while others consider this as a misguided belief (D7 S).

DISCUSSION

Common Ground With Previous Research and Future Perspectives

As expected, LEK of people plays a major role in shaping management practices together with other concrete elements of the worldview, such as the relevance of a given animal for a celebration (i.e., turkey) (van't Hooft and Flores-Farfán, 2012). People often specified to us when their management practices came from the knowledge inherited from their "grandparents" or ancestors. However, as documented in other regions, LEK is complemented (Giovannini et al., 2011) or replaced (Rangel-Landa et al., 2016) through the incorporation of non-local knowledge and practices, some of which can contribute to solve specific needs, while others can result in human, animal, and ecological damage (Olubukola et al., 2020). Taking an interpretive perspective has provided valuable elements for approaching to local fauna husbandry, extraction, coexistence, and conservation practices and for conceptualising socio-ecological questions and pathways

related to them (Drury et al., 2011; Newing et al., 2011; Castillo et al., 2020).

Fauna management involves changes through time, as worldview and LEK processes do (López-Austin, 1999; Berkes, 2008). In some cases, the legitimacy of ancient practices and regulations may become endangered due to changes in land tenure and use, work and agriculture dynamics, and/or the arrival of certain religious groups or military presence (González-Jácome, 2004; Santos-Fita et al., 2012; Flores-Armillas et al., 2020b). In this scenario, the incorporation of ecological approaches at population or community scale to biocultural conservation efforts do not provide a solution but can contribute to inform adaptive processes to reduce risk on animal populations. For example, since the use and management of Lepidoptera involve decisions on their host trees (Ramos-Elorduy et al., 2008; Escamilla-Prado et al., 2012; Molina-Nery et al., 2017), research efforts have been made to incorporate natural history, population and community ecology, and active propagation and cultivation of host plants to manage the edible Hepialidae (Hernández-Atlahua, 2015; Oltehua-Tzitzihua, 2016; Molina-Nery et al., 2017).

The main strength of our free listing work is that it shows the relative importance of mammals and snakes among a broad spectrum of animals relevant to people, from which only some elements have reports of use or damage. However, we sacrificed a detailed inventory within each recognised group of animals (Quinland, 2005; Meireles et al., 2021). Such an approach has been followed for herpetofauna in TC (Linares-Rosas et al., 2021), increasing the biocultural inventory for this group and is recommended as a further step for other animal Classes. Zoological inventories with a biocultural approach will not only contribute to confirm taxonomic identification but deepen human-fauna interactions beyond an utilitarian dimension.

While some human-fauna interactions can be highly predictable across an animal's distribution range, local singularities can take place. Our results are consistent with previous reports of extraction of mammals and birds in the Neotropics (Ojasti, 2000) and Lepidoptera in Mexico (Aldasoro-Maya and Gómez, 2016). At the same time, it is possible to distinguish local singularities between different ecosystems within the study area. For example, the fact that several mammals are used for attending births in TC is consistent with the spectrum of species reported in other regions of Mexico (Alonso-Castro, 2014). However, in the Sierra, only opossums are used with this purpose. Solitary and collective hunting expeditions, and waiting and using the aid of dogs to find and get animals are similar to other Neotropical Forest areas (Santos-Fita et al., 2012; de Paula et al., 2018). The sights and extraction of *C. paca* has been reported to be higher during dry season by people in Tabasco, México (Gallina et al., 2012) and in the Brazilian Cerrado (de Paula et al., 2018). This discrepancy with the permanent availability of paca reported in our results, could be explained if hunters travel to nearby areas to search paca throughout the year (Valsecchi et al., 2014). Gathering of Saturniidae and the Hepialidae genera *Phassus* sp. and *Schausiana* sp. (Lepidoptera) is similar to that reported for other regions from central to southern México, such as those in the Nahua and Tlahuica areas (Ramos-Elorduy et al., 2008; Escamilla-Prado et al., 2012; Gómez et al., 2015; Aldasoro-Maya and Gómez, 2016).

Local Ecological Knowledge-Based Coexistence Mechanisms

Animals engaged in human-fauna negative interactions with cattle, crops, and human health were in line with those previously reported for México (Flores-Armillas et al., 2020b). Besides, like in other regions in Mesoamerica, human-human conflicts can take the form of human-fauna negative interactions because of the beliefs about people taking the form of animals (Beaucage and Taller de Tradicion Oral del CEPEC, 2012). However, the effects of grazing on vegetation or the predation on native fauna (Ojasti, 2000) were not considered by people as a cause of concern.

Techniques of crop seed protection based on LEK suggest human learning to prevent damage or tolerate small losses without killing the predator animals (Carter and Linell, 2016). To better understand its foundations and the reasons for its abandonment, we encourage mixed ethnobiological and ecological chemistry approaches. However, after seed germination, damage control by hunting of mammals and quails follows the "garden hunting model," in that the extraction of animals attracted to crops (maize, beans, fruits) allow to complement a diet based in carbohydrates (Stahl, 2014). In an analogous way, wild animals attracted to domestic animals can also provide resources, unless they have been poisoned.

Our results suggest that the magnitude of the damage caused by white-nosed coati and deer in maize crop fields decreases as the distance to mature forest vegetation increases. Such relation has been already documented for tropical dry forest in central México (Flores-Armillas et al., 2020a) and we suggest further studies in the dynamic of fauna damages, their magnitude and the human tolerance towards it, incorporating land use dynamics at a landscape scale.

Local *Canis latrans* Say populations may have adapted (Lute and Carter, 2020) to the lack of human tolerance to damage by changing their home range area to overlap less with human activities and only sporadically feeding on cattle. It is likely that after fires, the presence of this and other animals has diminished only temporarily (Cunningham et al., 2006; Blancas et al., 2014; Pausas, 2019; Stevenson et al., 2019).

Recognition of spiritual beings (Lazos and Paré, 2000; González-Jácome, 2004; Beaucage and Taller de Tradicion Oral del CEPEC, 2012; Santos-Fita et al., 2015) and hunting bans in sacred sites (López-Austin, 1999; Schaaf and Rossler, 2010) have a role as mechanisms to avoid misuse and over-extraction of natural resources. This is likely the case in our study area, where the decrease of animal populations is attributed to anthropogenic factors. Therefore, spatial restrictions to fauna extraction also operate at the meta-community level and is related to group property (Ostrom et al., 1999). Rights on resource access are held by all members of a community who can exclude access to members of another community. However, regulations for fauna extraction within the community seem to be associated to private property of land and resource rights held by individuals who

exclude others (Ostrom et al., 1999). Although temporal bans were absent for hunting of white-tailed deer, their reproductive calendar is locally known and similar to that reported for tropical dry forest and shrubland of the Tehuacán-Cuicatlán Biosphere Reserve (López-Tello et al., 2015) and the north, western, and central México (Gallina-Tessaro et al., 2019).

Coexistence with fauna may engage in cognitive processing and cultural transmission dimensions (Albuquerque et al., 2020) that are not documented in this study case. For example, in Veracruz, México, music is dedicated to the white-nosed coati and to snakes to reduce damages to the milpa and to avoid snake bites while working (Nava-Vite, 2012). The celebration known as "*mapachi iljuitl*" (racoon party) provides a context in which elders give advice to youths about how to reduce damages by mammals in the milpa (Argüelles-Santiago, 2012). All these aspects are crucial to attending goals for biodiversity and biocultural diversity conservation.

A Local Intensity Gradient in the Human-Fauna Interactions

The management typology presented in this work is based on Melinda Zeder's frame of fauna management and domestication (Zeder, 2006). According to Zeder, a huge diversity of human-fauna management interactions is possible. In addition, on one side, each of these interactions may or not result in differential genetic and phenotypic-behavioural changes in fauna populations compared to those unmanaged populations. On the other side, these interactions can also result in the differential human investment (i.e., time, effort, social organisation, property rights, regulatory mechanisms) in labours directed to maintain animals, such as protecting animal populations or their habitats, taming individuals, feeding-grazing choices, or performing selective extraction or husbandry, and in the differential incorporation of managed animal populations to a socio-economic system. More precisely, with this work, we have provided an example of how even within a small spatial scale (<10 km), a diverse typology of management practices can arise, related to the knowledge of biodiversity and natural history and to the perceptions of benefit an animal can provide, the damage an animal can cause, and to cultural local criteria.

On one end of this gradient, we distinguished the extractive practices aimed to use or mitigate negative interactions with wild fauna, which show variations related to local regulatory mechanisms, to actions on elements engaged in ecological community processes (i.e., plant-host interactions in the case of edible Lepidoptera, successional dynamics in the case of Coleoptera plague prevention, local technology to prevent seed predation by mammals), and to the temporal captivity or relocation of individuals without its reproduction or taming. In the middle of the gradient, we would have located wild fauna husbandry. However, this was not the case in the studied localities. On the opposite end, we distinguished the husbandry practices towards domesticated animals, associated to health, reproduction and feeding choices. People may apply, or not, post-domestication artificial selection criteria, guided by cultural mechanisms and possibly favouring the proportion of some genetic or phenotypic traits. However, a question that was not directly addressed in this work is to what extent and in which direction the local biodiversity management practices act as selective pressures on wild and domestic fauna populations (Zeder, 2015).

Around the Global Value of Local Ecological Knowledge

The multiple forms of LEK around the world have been fundamental for human societies' subsistence. Each of them is a way of knowing the world beyond a utilitarian value (Nóbrega-Alves and Albuquerque, 2018). However, based on LEK, human societies have solved provisioning needs and coexistence with fauna.

Western science has increased its corpus of knowledge through LEK, a process that has been often dismissed. One example is the contribution of knowledge and specimens to the European natural history collections from worldwide expeditions (Alves and Silva, 2015). In a similar way, scientific literature in the last 10 years has evaluated and discussed the advantages of including LEK as a source of information to increase scientific knowledge. For example, in the case of fauna monitoring and conservation. Our work was not devoted to systematically researching about the people's perspective about Western science or their thoughts about how to articulate ecological knowledge (i.e., coming from different ontologies and epistemologies) (Reid et al., 2020). Rather, we adopted a perspective in which the "management" of biodiversity for conservation (including regulatory mechanisms and local technology) is already happening locally. It is LEK-based (Romero-Bautista et al., 2020; Solís and Casas, 2020; Rocha et al., 2021) and the "expert managers" are the *Mexicatl* inhabitants of the local communities.

As part of a scholar community of a public university, in a multicultural country, where at least 68 main languages and 364 linguistic variants are spoken (INALI, 2008), the authors hope to contribute to make visible the multiple bio-cultural approaches to fauna management. In such perspective, this work constitutes a modest approach to the ecological knowledge processes related to the local fauna management practices. These, in turn, have emerged as a set of diverse practices similar to what previous research has documented along three axes: a rich typology of adaptive LEK-based management practices (Berkes et al., 2000), the frame of human-fauna coexistence mechanisms (Madden, 2004; Carter and Linell, 2016), and a perspective of a gradient management-domestication typology (Zeder, 2006, 2015).

CONCLUSION

People are engaged in complex relations with wild and domestic fauna and perform local management practices within categories that can be framed in the management and domestication theory. Supply practices in the case of wild animals were extractive, and there was no evidence of reproduction in captivity. Management practices aimed to assure the availability of domestic animals, insects, and some wild vertebrates included agreements with land

and animal human right holders. However, extraction is also likely regulated by the recognition of rules and agreements with divine non-human owners. Better understanding of the strengths these rules and agreements have to prevent fauna extirpation would be needed.

We found evidence of the lack of tolerance to cattle losses attributed to *C. latrans*. However, the use of local technology based on LEK could be an example of co-adaptation for the coexistence with medium sized mammals. Negative human-fauna interactions involving domestic animals were mainly categorised as crop losses, attacks to cattle from feral dogs, and human-human disagreements.

Fauna management is expressed in a broad spectrum of practices and techniques, which all respond not only utilitarian or conflictive situations, but also to levels of interest of people on animals and their relevance in all dimensions of peoples' life. Presence, distribution, abundance, interactions with other organisms, plants, and animals are all relevant aspects that modulate interactions between people and fauna. Some general similarities are shared and more widely analysed with interactions and motivations related to plant management and domestication. An integrated theoretical synthesis about management and domestication of biodiversity is possible, and all these elements found and discussed here will be important for such a purpose.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Reserva de la Biosfera Tehuacán-Cuicatlán. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin. The animal study was reviewed and approved by Dirección de la Reserva de la Biosfera Tehuacán-Cuicatlán. Written informed consent was obtained from the owners for the participation of their animals in this study.

AUTHOR CONTRIBUTIONS

MZ-C and MC-G facilitated student workshops and systematised its results. MZ-C performed adult interviews, analysed fieldwork results, and prepared the first draft of the manuscript. AC was the main coordinator-supervisor of the research project and also contributed to all steps of the research and reviewed several drafts of the manuscript. MZ-C, MC-G, JP-M, and AC reviewed the manuscript and contributed conceptually to achieve its final version. All authors read and approved the final manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fevo.2022.760805/full#supplementary-material

Supplementary Additional File 1 | Relation of workshops and interviews, interview checklist, and list of animal images used for visual stimulus instrument (docx).

Supplementary Additional File 2 | Complete outputs of salience analysis (xlsx).

Supplementary Additional File 3 | Uses, management, human-fauna negative interactions, and animal diet as reported in student and adult interviews (xlsx).

Supplementary Additional File 4 | Singing to feed juvenile *M. gallopavo*. (a) woman in Sierra and (b) girl in Tierra Caliente (TC). (c) *Potos flavus* call mimicked by a boy in TC; (mp3).

Supplementary Additional File 5 | Simplified general management scheme. Use of fauna can become in human- fauna negative interactions if native animal populations are stressed or pushed towards local extirpation by human demand for wild fauna or domestic cattle (as perceived by interviewed people). Negative human-fauna interactions can become in human-human conflict. These three interactions are related to five local management categories intended to supply animal resources and mitigate the damages caused by fauna or human conflicts, but also to regulate fauna extraction. Figure elaborated with Cmap tools (https://cmap.ihmc.us/) (jpg).

Supplementary Additional File 6 | Environmental units in which presence of fauna was reported. Three categories of environmental units in which animals were reported to be present. Figure elaborated with Cmap tools (https://cmap.ihmc.us/) (jpg).

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