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Original paper

Wildlife use and harmful wild species in rural communities around the Communal Natural Protected Area El Gavilán, Oaxaca, Mexico

Uso de fauna silvestre y especies dañinas en comunidades rurales aledañas al Área Natural Protegida Comunitaria El Gavilán, Oaxaca, México

[1]*Jesús García-Grajales, [2]Carlos Alberto Luis-Curiel, [1]Alejandra Buenrostro-Silva

[1]Instituto de Recursos/Instituto de Industrias, Universidad del Mar campus Puerto Escondido, Km. 2.5 Carretera Federal Puerto Escondido – Sola de Vega, Puerto Escondido, C.P. 71980, San Pedro Mixtepec, Oaxaca, México.
[2]Licenciatura en Biología, Universidad del Mar campus Puerto Escondido, Km. 2.5 Carretera Federal Puerto Escondido – Sola de Vega, Puerto Escondido, C.P. 71980, San Pedro Mixtepec, Oaxaca, México.

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ABSTRACT. A large portion of rural human residents in Mexico are established in the states with greater biological diversity, and continue using a variety of wildlife species as sources of protein, fat, medicinal substances, clothes, adornments, ritual objects, and income, among other purposes. Our aims in this study were: 1) identify the main wildlife species that are part of local knowledge and are used, 2) describe the hunting techniques used by inhabitants of rural communities, and 3) identify the main wildlife species considered harmful between two groups of inhabitants of rural communities settled around the Communal Natural Protected Area El Gavilán on the central coast of Oaxaca, in southwest Mexico. We conducted fieldwork during four visits to the communities between June and December 2015. We obtained information through open conversations with structured and in-depth interviews. We calculated the Importance Culture Index (ICI) and the Importance Damage Index (IDI) per wildlife species. We recorded 51 wild species, which are part of the knowledge of the

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***Corresponding author:**
Jesús García-Grajales
archosaurio@yahoo.com.mx

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studied communities, and seven different uses were identified. There was no significant difference in the knowledge of wildlife among the study groups, but there was a significant difference in the use of wildlife. In general, the inhabitants of the communities around the NPA El Gavilán have extensive knowledge and make use of its wildlife, but there are differences in the uses of these species. Here we present a synthesis of the most relevant knowledge and uses of wildlife in communities around a natural protected area.

Key words: interviewees; importance culture index; importance damage index; knowledge; use

RESUMEN. En México una gran proporción de habitantes de áreas rurales están establecidos en los estados con mayor diversidad biológica y continúan usando una gran variedad de especies de vida silvestre como fuentes de proteína, grasa, sustancias medicinales, ropa, herramienta, adornos, objetos para rituales e ingresos, entre otros propósitos. Los objetivos de este estudio fueron: 1) identificar a las principales especies de fauna que son parte del conocimiento local y son usadas, 2) describir las técnicas de cacería utilizadas por los habitantes de las comunidades rurales, y 3) identificar las principales especies de fauna consideradas como dañinas entre dos grupos de habitantes de las comunidades rurales aledañas al Área Natural Protegida Comunal (ANPC) El Gavilán, en la costa de Oaxaca, México. Realizamos el trabajo de campo durante cuatro visitas a las comunidades entre junio y diciembre de 2015. Obtuvimos información a través de conversaciones abiertas con apoyo de entrevistas semiestructuradas. Calculamos el Índice de Importancia Cultural (IDC) y el Índice de Importancia de Daño (IDD) por especies de fauna. Registramos un total de 51 especies de fauna silvestre, las cuales son parte del conocimiento de las comunidades estudiadas, así como siete diferentes usos fueron identificados. No existieron diferencias significativas en el conocimiento de la fauna silvestre entre los grupos estudiados. En general, los habitantes de las comunidades aledañas al ANPC El Gavilán tienen un extenso conocimiento y formas de uso de la fauna silvestre, pero existen diferencias en los usos de estas especies. Aquí presentamos una síntesis de los conocimientos y usos más relevantes de la fauna silvestre en las comunidades alrededor de un área natural protegida.

Palabras clave: entrevistas; índice de importancia cultura; índice de importancia de daño; conocimiento; uso

INTRODUCTION

Humans share the world with a high diversity of species, and throughout history all societies have established a fundamental connection with wildlife (Allaby, 2010; Kalof & Resl, 2007), creating a spatial co-occurrence among biological, ecological, environmental, geographical, linguistic, and cultural components (Loh & Harmon, 2005; Maffi, 2007; Harmon & Loh, 2010; Gutiérrez-Santillán *et al*., 2019). In addition, the relationship between humans and their environment has made it possible to accumulate knowledge, practices, and beliefs, which changes over time through an adaptative process (Guerrero-Gatica *et al*., 2020); but, in recent decades human settlements have increased in size and number causing a closer approach to wildlife areas (Songhurst & Coulson, 2014). As a result, a variety of wild vertebrates are responsible for crop-damage (Romero-Balderas *et al*., 2006; Songhurst & Coulson, 2014).

In this context, wildlife is a constantly used resource for humans and a subject of management practices because of its multiple values, which depend on each taxonomic group and its specific historical and geographical context (Pérez-Gil *et al*., 1995; Monroy-Vilchis *et al*., 2008). In Mexico, a large portion of rural human residents and ethnic groups are settled in the states with greater biological diversity, mostly in tropical forests and temperate forests and, to a lesser extent, in arid and semi-arid areas (Toledo *et al*., 2002). This proximity between human communities and wildlife has enabled the creation of a diversity relationships and partnerships, translating into a knowledge that includes the perception, use, and management of wildlife (Hunn, 2011; Gutiérrez-Santillán *et al*., 2017). Currently, human communities continue to use a variety of wildlife species as sources of protein, fat, medicinal substances, clothes, tools, adornments, ritual objects, and income, among other purposes (Redford & Robinson, 1991; Ojasti, 2000; Santos-Fita *et al*., 2012). On the other hand, many wildlife species have been reported to cause crop damage in different parts of the world (Songhurst & Coulson, 2014); therefore, rural farmers face the need to reduce crop damage caused by wildlife (Osborn & Hill, 2005).

In Mexico, several wild fauna species are used for different purposes (Gutiérrez-Santillán *et al*., 2019). Most are obtained through hunting, which is considered an activity when its primary purpose is to satisfy the hunters and their families' basic needs (Jorgenson, 1995; Ojasti, 2000). The reported types of wildlife use are personal consumption or for sale of meat, skins for clothes, pets, and medicinal substances (Naranjo *et al*., 2004; Machkour *et al*., 2011; Santos-Fita *et al*., 2012; Perezgrovas, 2014).

Among the wild terrestrial vertebrates that provide food and other products to rural inhabitants in the Neotropics are ungulates, primates, armadillos, and large rodents, as well as psitacids, iguanas, fresh-water turtles, and crocodiles (Bodmer *et al*., 1997; Nahuat *et al*., 2021). However, the overhunting of these species may induce severe decreases in their population sizes, potentially leading to their local extinction, especially if they face habitat loss, degradation, and fragmentation (Redford, 1992; Santos-Fita *et al*., 2012). In Mexico, it is possible that these threats are slowing down due to the local initiatives, like the creation of Communal Natural Protected Areas under the program of Áreas Certificadas para la Conservación, which in this region covers a total of 23,437 ha (Ortega *et al*., 2010; Monterrubio-Solís 2019). This is a new form of natural protected areas based on conservation efforts by landowners (private or collective), and benefits wildlife survival, mainly those that are endemic to the country and are nationally or internationally threatened (Monterrubio-Solís, 2019).

In the state of Oaxaca, over 60 species of wild mammals, birds and reptiles are used by local communities in Sierra Norte, Tehuacán-Cuicatlán valley, La Mixteca and the Istmo de Tehuantepec (Contreras-Díaz & Pérez-Lustre, 2008; Flores-Manzanero *et al*., 2013; Zarazúa-Carbajal *et al*., 2020). However, although the Oaxaca coast has a great diversity of ethnic cultures (Barabas, 2008), only one study on the coast of Oaxaca has focused on assessing the use of wildlife in a natural protected area (Buenrostro-Silva *et al*., 2016), and another study evaluated the local perception of rural communities about crocodiles living in the Parque Nacional Lagunas de Chacahua (García-Grajales & Buenrostro-Silva, 2015). In addition, the establishment of a Communal Natural Protected Area (CNPA) can produce profound changes in the perception of

the environment by human communities in rural areas; however, it should be noted that there are two types of inhabitants in communities around a CNPA, 1) those who are linked through conservation activities to protect and preserve the CNPA, through surveillance, monitoring, and actions aimed at preserving the site; and 2) those who do not have any link with the CNPA. Moreover, under the approach of biocultural diversity, which is understood as the variety of organisms that are known, named, classified, organized, used, exploited, domesticated, and/or manipulated by different human societies (Gutiérrez-Santillán *et al*., 2019), it is very important to improve and update our understanding about the current practices of wildlife use by resident communities to support better management strategies for conserving species and their habitats based on scientific and traditional knowledge. With this background, our aim in this study was to examine the use of wildlife by two groups of inhabitants (i.e., people involved and people non-involved in conservation actions) of rural communities settled around the Communal Natural Protected Area El Gavilán on the central coast of Oaxaca (Mexico). Specifically, we: 1) identify the main wildlife species that are part of local knowledge and are used by inhabitants; 2) describe the hunting techniques used by inhabitants of rural communities; and 3) identify the main wildlife species considered harmful.

MATERIALS AND METHODS

Study area. This study was carried out in ten rural villages (Table 1) settled around the Comunal Natural Protected Area (CNPA) El Gavilán, located in Santa María Tonameca municipality on the central coast of Oaxaca, Mexico (Fig. 1). These villages are surrounded by extensive tracts of tropical dry forest with secondary vegetation, croplands, and some induced grasslands for livestock production. The central coast of Oaxaca has a warm and subhumid climate with most rains (600–1200 mm) falling between July and October. The mean annual temperature is 26 °C (García, 1988).

The villages have *ca*. 500 inhabitants and were founded in the decade of 1960 by the immigrants of Santa María Tonameca municipality. Most of the inhabitants of these villages are Zapotecan descendants and are farmers that harvest corn, beans, and squash for their subsistence. Papaya and watermelon are commercial crops in the area. Other economic activities are palm leaves and livestock production, transportation services, and small grocery stores.

Fieldwork. The fieldwork was conducted during four visits to ten rural communities between June and December 2015. Information was obtained through open conversations with semi-structured and in-depth interviews (Bernard, 2006; Albuquerque *et al*., 2014), which included questions aimed at studying knowledge and questions aimed at determining the use of fauna. The second technique (in-depth) was used in parallel to obtain details about the species that are used and descriptions of the hunting techniques. At each interview, consent was obtained from the informants (Albuquerque *et al*., 2014). One person in each village served as a guide for gaining confidence from local interviewees and their families and thus get information about their wildlife use and management practices (Santos-Fita *et al*., 2012). A total of forty-one interviews were performed in the rural communities around the CNPA El Gavilán; twenty interviews were

conducted with people associated with the conservation area, and 21 interviews were carried out with people with no connection to the conservation area.

Table 1. Characteristics of rural communities that live near the CNPA El Gavilán, Oaxaca, Mexico.

No.	Communities	Males	Females	Total inhabitants	Number of houses
1	El Limón	69	98	167	28
2	El Mangal	5	6	11	3
3	El Paraíso	112	108	220	38
4	La Unión	31	32	63	17
5	Las Pilas I	63	58	121	23
6	Las Pilas II			No data	
7	Paso Ocote	117	96	213	40
8	San Francisco Cozoaltepec	993	1128	2121	475
9	Valdeflores	194	192	386	75
10	Villa Nueva	50	38	88	15

For the identification of species used or cited by informants, during interviews we showed photographs previously taken by the authors (Santos-Fita *et al*., 2012), as well as color plates from field guides (Ceballos & Oliva, 2005; Howell & Webb, 2005; Köhler, 2008).

Data analysis. The categories of wildlife use were established based on the use reported by informants. Seven categories were identified: food, medicinal, commercial, ornamental, utensil, mythical, and pet use. The records obtained for use of wildlife and knowledge were organized in an Excel sheet, by analyzing cross variables between the two groups of interviewees and the chi-square statistic (Osbahr & Morales, 2012).

We calculated the Importance Culture Index (*ICI*) for each wildlife species following the López and Valdez-Hernández (2011) formula. For this, first we calculated the subscripts: A) the Relative Intensity of use (*RIu*) as the percentage of uses in which a species appears (*RIu* = (Uz/U) *100; where Uz is the number of uses of species z for all respondents, and U is the total number of uses listed for all species; B) Relative Frequency of mention (*RFm*) as $RFm = (\mathrm{z} / \sum \mathrm{z})$, defined as the sum of mentions for one species (z) considering all uses and all informants (Garibay *et al*., 2007); and C) the Relative Value of Use ($RVu_x = \left(\frac{u_{zx}}{u_x}\right) * 100$) as the percentage of uses in which a species appears for a given use, where U_{zx} is the number of species z for a certain use x by all informants, and Ux is total number of mentions of all species for use by all informants. With *Vux*, it was possible calculate the value of the total use of all species (Vutz= ∑ Vux). We then calculated the value of *ICI* as the sum of *RIu* (Relative Intensity of Use), *RFm* (Relative Frequency of Mention), and $RVut_z$ (Relative Value of total Use of all species) divided by three (i.e., ICI= $(RIu + RFm + RVu_{tz}rel)/3$) (López & Valdez-Hernández, 2011).

On other hand, we calculated the harmful index (*HI*) as those harmful species mentioned by informants using the *ICI* formula, replacing the use values with those related to harm. Although this index can be considered subjective, it may be a good indicator of the species considered to be harmful (López & Valdez-Hernández, 2011).

Lastly, to determine the relationships between uses and harm by wildlife species, a correspondence analysis (CA) was carried out. The analysis considered the variables (ICI and HI) and those species most often mentioned. The 20 species with higher explanatory value in the CA were used to illustrate these relationships, as they accounted for 78.17% of the variation in the CA. This analysis was conducted with the R software version 1.4.1717 (R Core Team, 2013).

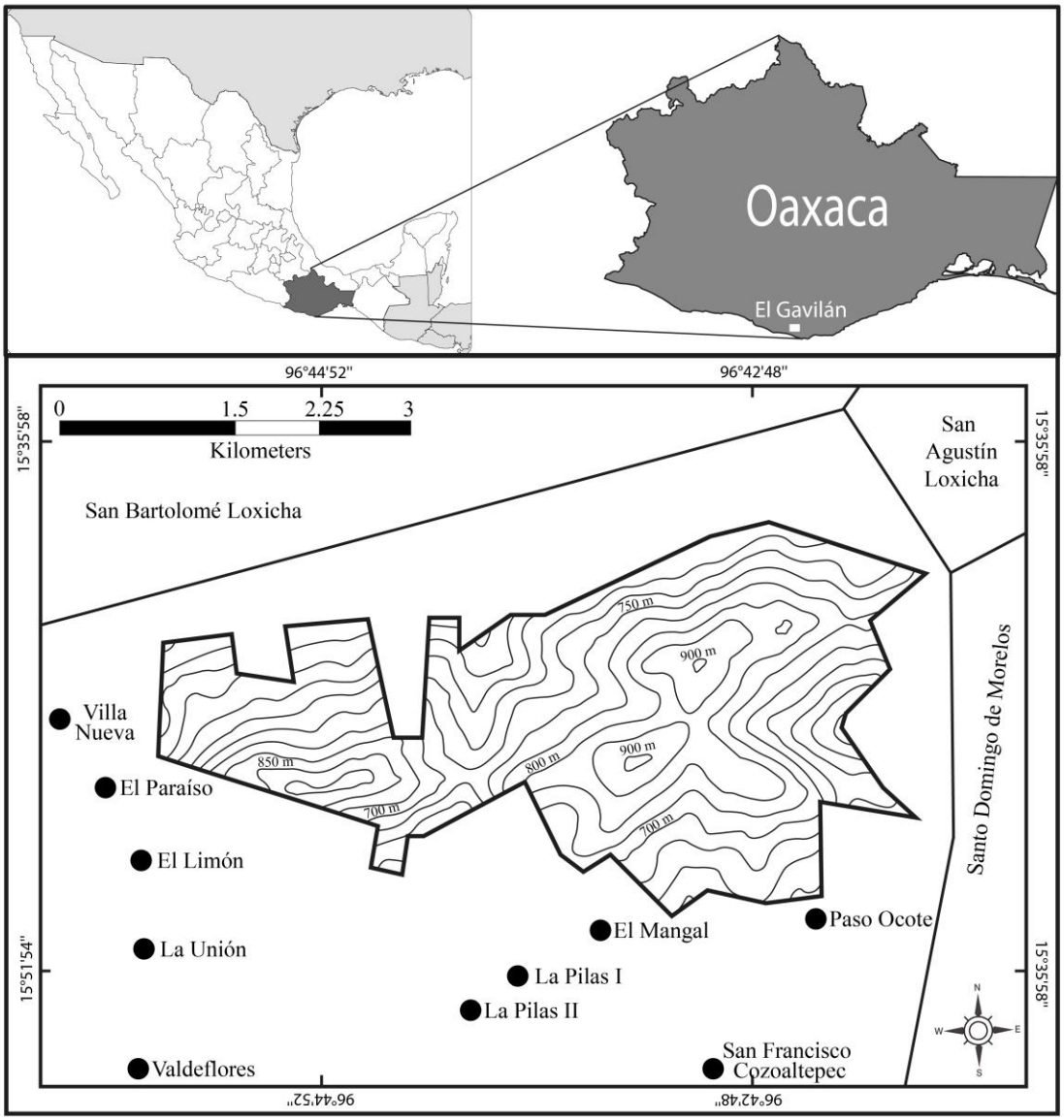

Figure 1. Location of the communities around the CNPA El Gavilán, Oaxaca, Mexico. Black circles show the location of rural villages and thick black line shows the area of the CNPA El Gavilán.

RESULTS

We recorded 51 wild species which were part of the knowledge of the study communities: 21 mammals, 14 birds, eight reptiles, one amphibian, one arachnid, three species of insects, one species of centipede, and two species of crustaceans (Table 2). There was no significant difference in the knowledge of wildlife between the study groups (t = -1.9, g.l. = 38.8, p = 0.060) but people without a link with the CNPA used more wildlife that those associated with the CNPA (x^2 = 18.7, g.l. = 6, p = 0.005).

The interviewees recognized a total of 44 species with some type of use. We recorded seven different uses: food, medicinal products, pets, commercial use, ornamental, utensils, and mythical purposes.

According to *ICI*, *Odocoileus virginianus* (Zimmermann, 1780) (ICI = 9.32%), *Dasypus novemcinctus* (Linnaeus, 1758) (ICI = 6.49%), *Eupsittula canicularis* (Linnaeus, 1758) (ICI = 4.63%), *Atta mexicana* (Linnaeus, 1758) (ICI = 4.60%), and *Tamandua mexicana* (Saussure, 1860) (ICI = 4.44%; Table 3) were the species with the most cultural importance. On the other hand, *O. virginianus* (Iu = 85.71%), *D. novemcinctus* (Iu = 57.14%), *T. mexicana* (Iu = 57.14%), *Leopardus wiedii* (Schinz, 1821) (Iu = 57.14%), and *E. canicularis* (Iu = 42.86%) were the species with the highest intensity of use (Table 4).

According to the value of use, the species with the highest value were *A. mexicana* (Formicidae, Vux = 7.12%), *Ctenosaura pectinata* (Wiegmann, 1834) (Vux = 7.12%), *Ortalis poliocephala* (Wagler, 1830) (Vux = 6.73%), and *Dicotyles angulatus* (Linnaeus, 1758) (Vux = 5.96%; Table 5).

With respect to medicinal use, twelve species were registered for the treatment of 24 diseases or physical inflictions. The species with the highest value of medicinal use were skunks (Mephitidae, Vux = 32.08%), *Crotalus simus* (Latreille, 1801) (Vux = 24.53%), vultures (Cathartidae, Vux = 16.04%), and *Didelphis virginiana* (Kerr, 1792) (Vux = 12.26%; Table 6). On the other hand, 11 species were recorded as pets *E. canicularis* (Vux = 43.64%), *O. poliocephala* (Vux = 16.36%), *Nasua narica* (Linnaeus, 1766) (Vux = 9.09 %), *O. virginianus* (Vux = 9.09%), and *Sciurus aureogaster* (Linnaeus, 1758) (Vux = 9.09%) were the most used species as pets (Table 6). On the other hand, 12 species were recorded for commercial use and *A. mexicana* (Formicidae: Vux = 28.57%), *O. virginianus* (Vux = 21.73%), and *L. wiedii* (Vux = 10.71%) were the species most often used commercially.

Eleven species are hunted to be used as ornaments or utensils, including *L. wiedii* (Vux = 20.59%), *O. virginianus* (Vux = 17.65%), and *D. novemcinctus*: (Vux = 14.71%) with the most ornamental uses. As part of the beliefs and customs (mytical use) of the communities around CNPA El Gavilán, two species were attributed to physical strength, such as *T. mexicana* (Vux = 27.27%), *D. virginiana* (Vux = 09.09%), while *Panthera onca* (Linnaeus, 1758) (Vux = 18.18%), and vultures (Cathartidae, Vux = 18.18%) were associated with good luck, and the pygmy-owl (*Glaucidium brasilianum*) and *Canis latrans* (Say, 1823) (Vux = 9.09%) were associated with bad luck.

According to the 41 interviewers, hunting is practiced sporadically, particularly during trips to their working plots or in special days (weddings, birthdays, or school graduations). Seven species were recorded as the most preferred to hunt, with *O. virginianus*, *D. angulatus*, and *O. poliocephala* being the principal species mentioned.

Diurnal active search with the use of guns (0.22 caliber rifles and shotguns) was the most frequent hunting technique, followed by nocturnal waiting in trees using flashlights and guns for shooting deer (*O. virginianus*) and peccaries (*D. angulatus*). Additionally, using trained dogs to find *D. novemcinctus*, *Iguana iguana* (Linnaeus, 1758) and *C. pectinata* in burrows was another technique recorded. Moreover, occasional group-hunting trips of up to 10 people form a noisy drive so that potential prey come out are killed at a strategic point by waiting shooters along pathways used by the animals (arreada) is a local technique of deer hunting used in special days to obtain food.

Twenty-nine species were recorded as harmful wildlife, and species with the highest intensity of damage (*HI*) were *Calocitta formosa* (Swainson, 1827) (*HI* = 30%), skunks (Mephitidae, *HI* = 30%) and *D. virginiana* (*HI* = 30%), which cause damage to crops (frijolar and corn) and poultry.

According to the CA, the first two dimensions of the association between the use and damage of wildlife explained 78.17% of the cumulative variance (Fig. 2). For uses, the association of species was greater with food, commercial use, ornamental, utensil, and pets; while species that cause damage to corn crops were also associated with pet and food use. Species causing damage to beans were also related to ornamental, commercial, food, and utensil use. Damage to poultry was not related to any use variable.

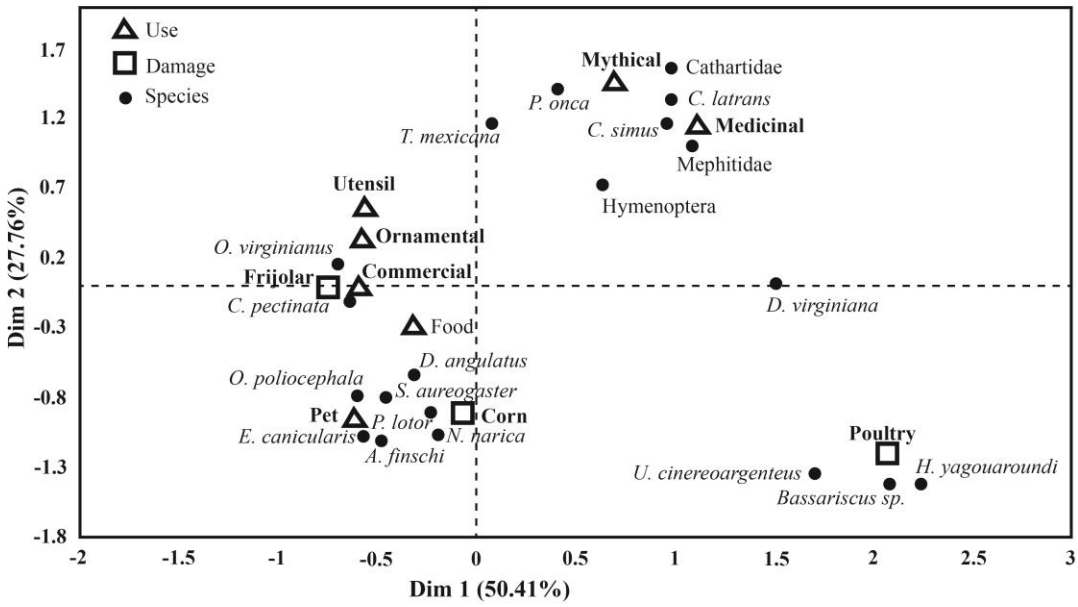

Figure 2. Correspondence Analysis (CA) between the variables of use and harm of wildlife species in the communities around the CNPA El Gavilán, Mexico.

Table 2. List of wildlife species that are known by rural communities that live near the CNPA El Gavilán, Oaxaca, Mexico.

Biological group	Order	Family	Scientific name	Local name
MAMMALIA	Didelphimorphia	Didelphidae	*Didelphis virginiana*	Tlacuache
	Cingulata	Dasypodidae	*Dasypus novemcinctus*	Armadillo
	Pilosa	Myrmecophagidae	*Tamandua mexicana*	Oso hormiguero, chupamiel, 14 fuerzas
	Chiroptera	Phyllostomidae	*Desmodus rotundus*	Murciélago
	Carnivora	Felidae	*Leopardus pardalis*	Ocelote
			Leopardus wiedii	Tigrillo
			Herpailurus yagouaroundi	Onza
			Panthera onca	Jaguar, tigre
		Canidae	*Canis latrans*	Coyote
			Urocyon cinereoargenteus	Costoche, zorra
		Mephitidae	*Conepatus leuconotus/Spilogale pygmaea*	Zorrillos
		Procyonidae	*Potos flavus*	Martucha
			Bassariscus sp.	Jiquimilla
			Nasua narica	Tejón, coatí
			Procyon lotor	Mapache
	Artiodactyla	Tayassuidae	*Dicotyles angulatus*	Jabalí, cuche de monte
		Cervidae	*Odocoileus virginianus*	Venado
	Rodentia	Sciuridae	*Sciurus aureogaster*	Ardilla
		Geomyidae	*Orthogeomys* sp.	Tuza
		Erethizontidae	*Coendou mexicanus*	Puerco espín
	Lagomorpha	Leporidae	*Sylvilagus* sp.	Conejo
AVES	Accipitriformes	Accipitridae	*Micrastur semitorquatus*	Gavilán
		Cathartidae	*Cathartes aura/Coragyps atratus*	Zopilote
	Galliformes	Cracidae	*Ortalis poliocephala*	Chachalaca
		Odontophoridae	*Colinus virginianus*	Codorniz

Biological group	Order	Family	Scientific name	Local name
	Columbiformes	Columbidae		Palomas
			Columbina inca	Tortolita
	Psittaciformes	Psittacidae	*Eupsittula canicularis*	Perico
			Amazona finschi	Cotorra
	Strigiformes	Strigidae		Tecolote
		Trochilidae		Colibrí
	Piciformes	Ramphastidae	*Aulacorhynchus prasinus*	Tucán, perico real
		Picidae		Carpintero
	Passeriformes	Corvidae	*Calocitta formosa*	Urraca
		Icteridae	*Quiscalus mexicanus*	Zanate
REPTILIA	Testudines			Tortuga de rio
	Squamata	Iguanidae	*Ctenosaura pectinata*	Iguana negra
			Iguana iguana	Iguana verde
		Helodermatide	*Heloderma horridum*	Escorpión
		Boidae	*Boa imperator*	Boa
		Veiperidae	*Agkistrodon bilineatus*	Embosalada
			Crotalus simus	Cascabel
			Porthidium dunni	Chatilla
AMPHIBIA	Anura			Ranas
ARACHNIDA	Araneae	Nephilidae	*Nephila* sp.	Araña
INSECTA	Hymenoptera			Avispas
		Formicidae		Chicatana
	Orthoptera			Chapulines
CHILOPODA	Scolopendromorpha	Scolopendridae	*Scolopendra* sp.	40 manos
MALACOSTRACA	Decapoda			Camarón de rio
				Cangrejos

Table 3. Species with the highest Importance Culture Index (ICI) for the rural communities that live near the CNPA El Gavilán, Oaxaca, Mexico. *RIu* = Relative Intensity of use; *RFm* = Relative Frequency of mention; RVu_{tz} = Relative Value of Use; *ICI* = Importance Culture Index.

No.	Scientific name	Common local name	*RIu*	*RFm*	RVu_{tz}	*ICI*
1	*Odocoileus virginianus*	Venado	6.45	7.64	13.88	9.32
2	*Dasypus novemcinctus*	Armadillo	4.30	6.06	9.12	6.49
3	*Eupsittula canicularis*	Perico	3.23	3.82	6.85	4.63
4	Formicidae	Chicatana	2.15	6.46	5.21	4.60
5	*Tamandua mexicana*	Oso hormiguero, chupamiel, 14 fuerzas	4.30	1.32	7.70	4.44
6	*Ortalis poliocephala*	Chachalaca	3.23	5.93	3.81	4.32
7	Mephitidae	Zorrillos	2.15	5.53	4.80	4.16
8	*Crotalus simus*	Cascabel	3.23	4.08	4.12	3.81
9	*Leopardus wiedii*	Tigrillo	4.30	1.71	4.79	3.60
10	Cathartidae	Zopilote	3.23	2.64	4.92	3.59
	Another 34 species*		63.44	54.81	34.80	51.02
			100%	100%	100%	100%

Table 4. Species with the highest intensity of use by rural communities that live near the CNPA El Gavilán, Oaxaca, Mexico. Fm = Frequency of mention, Iu = Intensity of use; Med = Medicinal, Comm = Commercial, Orn = Ornamental, Ute = Utensil, Myt = Mythical.

No.	Scientific name	Common local name	Uses	No. uses	*Fm*	*Iu* %
1	*Odocoileus virginianus*	Venado	Food, Med, Pet, Comm, Orn, Ute	6	58	85.71
2	*Dasypus novemcinctus*	Armadillo	Food, Pet, Orn, Ute	4	46	57.14
3	*Tamandua mexicana*	Oso hormiguero, chupamiel, 14 fuerzas	Food, Orn, Ute, Myt	4	10	57.14
4	*Leopardus wiedii*	Tigrillo	Food, Pet, Comm, Orn	4	13	57.14
5	*Eupsittula canicularis*	Perico	Food, Pet, Comm	3	29	42.86
6	*Ortalis poliocephala*	Chachalaca	Food, Pet, Comm	3	45	42.86
7	*Crotalus simus*	Cascabel	Food, Pet, Comm	3	31	42.86
8	Cathartidae	Zopilote	Food, Pet, Myt	3	20	42.86
9	*Sciurus aureogaster*	Ardilla	Food, Pet, Orn	3	30	42.86
10	*Dicotyles angulatus*	Jabalí, cuche de monte	Food, Comm, Orn	3	33	42.86

Table 5. Value of use of wildlife for rural communities that live near the CNPA El Gavilán, Oaxaca, Mexico. Med = Medicinal, Comm = Commercial, Orn = Ornamental, Ute = Utensil, Myt = Mythical.

No.	Taxonomic category	Common local name	Food	Med	Pet	Comm	Orn	Ute	Myt
1	*Didelphis virginiana*	Tlacuache	2.88	12.26					9.09
2	*Dasypus novemcinctus*	Armadillo	7.31		1.82		14.71	40.0	
3	*Tamandua mexicana*	Oso hormiguero, chupamiel, 14 fuerzas	0.77				5.88	20.0	27.27
4	*Leopardus pardalis*	Ocelote	0.19			3.57	11.76		
5	*Leopardus wiedii*	Tigrillo	0.38		1.82	10.71	20.59		
6	*Herpailurus yagouaroundi*	Onza	0.96						
7	*Panthera onca*	Jaguar, tigre	0.19				5.88		18.18
8	*Canis latrans*	Coyote		0.94					9.09
9	*Urocyon cinereoargenteus*	Costoche	0.77						
10	Mephitidae	Zorrillos	1.54	32.08					
11	*Potos flavus*	Martucha	0.96		1.82		11.76		
12	*Bassariscu* sp.	Jiquimilla	0.19						
13	*Nasua narica*	Tejón, coatí	4.42		9.09				
14	*Procyon lotor*	Mapache	3.46						
15	*Dicotyles angulatus*	Jabalí, cuche de monte	5.96			3.57	2.94		
16	*Odocoileus virginianus*	Venado	7.12	1.89	9.09	21.43	17.65	40.0	
17	*Sciurus aureogaster*	Ardilla	4.62		9.09		2.94		
18	*Orthogeom* sp.	Tuza	3.46						
19	*Coendou mexicanus*	Puerco espín	3.46	1.89					
20	*Sylvilagus* sp.	Conejo	3.65				2.94		
21	Cathartidae	Zopilote	0.19	16.04					18.18
22	*Ortalis poliocephala*	Chachalaca	6.73		16.36	3.57			
23	*Colinus virginianus*	Codorniz	4.42		1.82				
25	Columbidae	Palomas	4.04		1.82				
25	*Columbina inca*	Tortolita	1.15						
26	*Eupsittula canicularis*	Perico	0.77		43.64	3.57			
27	*Amazona finschi*	Cotorra	0.19		3.64				
28	Strigidae	Tecolote							18.18

No.	Taxonomic category	Common local name	Food	Med	Pet	Comm	Orn	Ute	Myt
29	Trochilidae	Colibrí		0.94					
30	*Aulacorhynchus prasinus*	Tucán, perico real	0.58	3.77		3.57			
31	Picidae	Carpintero	0.77				2.94		
32	*Quiscalus mexicanus*	Zanate	0.19						
33	Testudines	Tortuga de rio	0.19	0.94					
34	*Ctenosaura pectinata*	Iguana negra	7.12			7.14			
35	*Iguana iguana*	Iguana verde	5.00			7.14			
36	*Boa imperator*	Boa	0.19			3.57			
37	*Crotalus simus*	Cascabel	0.77	24.53		3.57			
38	Anura	Ranas	1.35						
39	*Nephila* sp.	Araña	0.96						
40	Hymenoptera	Avispas	2.31	3.77					
41	Formicidae	Chicatana	7.88			28.57			
42	Orthoptera	Chapulines	2.12						
43	Decapoda	Camarones de rio	0.77						
44	Decapoda	Cangrejo		0.94					
			100%	100%	100%	100%	100%	100%	100%

DISCUSSION

The rural inhabitants of southwestern Mexico have good knowledge of the biological and behavioral aspects of wildlife in their communities, which often leads to specific uses (Santos-Fita *et al*., 2012). In this study, knowledge of wildlife did not vary according to involvement in conservation actions (i.e., with or without links to the CNPA El Gavilán). This is probably because all interviewees coexist in a labor environment based mainly on agriculture in the surroundings of the CNPA El Gavilán. The interactions with wildlife were equitable between groups. Nonetheless, the significant difference in the use of wildlife between groups could be attributed to conservation actions by a group of people, such as surveillance monitoring and firebreaks. Yet, given the small sample of people that were interviewed these results should be taken with caution and confirmed by future research.

Four principal uses were detected in our work (food, medicinal use, pets, and commercial use), but in other studies in Mexico other uses are mentioned such as ornamental, peeler, mythical, handicraft, narrative, artistic, presage, and avoiding damage effects (Naranjo *et al*., 2004; Racero-Casarrubia *et al*., 2008; Centeno & Arriaga, 2010; González-Bocanegra *et al*., 2011; Puc & Retana, 2012; Lira-Torres *et al*., 2014; García del Valle *et al*., 2015; Buenrostro-Silva *et al*., 2016; Zarazúa-Carbajal *et al*., 2020; Nahuat *et al*., 2021; Valle *et al*., 2021), the difference may probably be attributed to cultural differences that exist by regions of the country.

Recent studies show that the most common purpose of hunting is obtaining food (Zarazúa-Carbajal *et al*., 2020; Nahuat *et al*., 2021; Valle *et al*., 2021), and in our study it was the main use of wildlife. Clearly, one of the most fundamental uses of animals is to meet nutritional needs (Reitz & Wing, 2008). In marginalized areas, animal protein is often a luxury; depending on the ability of the villagers to acquire the meat, wildlife becomes an important addition to the native food of the people (Ojasti, 2000). Nontheless, on special days, such as weddings, birthdays, or school graduations, occasional group-hunting trips of up to 10 people form a noisy drive so that potential prey come out are killed at a strategic point by waiting shooters along pathways used by the animals. This local technique is called "arreada" (Valle *et al*., 2021). Meat and fish have been the primary source of protein for many human cultures throughout history (Gross, 1975) and although vertebrates constitute most of the terrestrial wild animal biomass consumed by humans (Nasi *et al*., 2008), this study indicated that invertebrates can be locally important dietary items, such as *Atta mexicana* (Landero-Torres *et al*., 2005; Martínez-Sánchez *et al*., 2019).

Of the main vertebrate groups targeted by hunting activities, the most prominent are mammals, birds, and reptiles (Robinson & Redford, 1991; Klemens & Thorbajarnarson, 1995; Buenrostro-Silva *et al*., 2016; Zarazúa-Carbajal *et al*., 2020; Nahuat *et al*., 2021; Valle *et al*., 2021). Mammals are the preferred source of food because of their size and the possibility of yielding a greater return for the energy invested in hunting (Albuquerque *et al*., 2012). In those areas where there is not an abundance of large-sized mammals, other vertebrates like birds are hunted (Mendoza, 2012). In El Gavilán, *Orthalis poliocephala* is the species of birds used for consumption when there are low populations of mammals.

The treatment of illnesses using animal-based remedies is an ancentral practice (Chemas, 2010; Valle *et al*., 2021). Whole animals, animal parts, and animal-derived products also constitute important elements in the medicinal knowledge of rural communities (Nóbrega-Alves, 2012; Pineda-Posadas *et al*., 2021). In the communities around the natural protected area, mammals such as skunks and opossums, birds such as vultures, and reptiles such as snakes (including threatened species such as *C. simus*), are prominent among the main animals used in traditional medicine, substantiating the importance of understanding such uses in the context of animal conservation (Nóbrega-Alves, 2012). In recent years, however, an important number of animals and plants used in traditional medicine faces threats ranging from habitat loss to the global wildlife trade (Cleva, 2006). Additionally, whereas traditional medicine used to be a localized practice, the globalization of commerce in combination with the increased popularity of natural approaches to health worldwide has created a level of demand that threatens the survival of many vulnerable species of wildlife (IFAW, 2011).

Guerrero and Retana (2012) mention the use of wasp piquettes (Hymenoptera) for the treatment of rheums, using vultures (Cathartidae) to treat epileptic rage and attacks, utilizing opossums (*D. virginiana*) for the treatment of cough, the use of deers (*O. virginianus*) for fertility and using skunks (*Mephitis macroura*) for headache and muscle pain. Moreover, García-Flores *et al*. (2014) and Rodas-Trejo *et al*. (2014) point to the opossums for the treatment of muscle pain. In several parts of Mexico, the use of the rattlesnake (*Crotalus* sp.) has been reported to display anti-carcinogenic properties (Gómez & Pacheco, 2010; Monroy-Vilchis *et al*., 2008; Reyna *et al*., 2015). In our study, similar medicinal uses were obtained and additionally, we document other sufferings that are treated with different parts or derivatives of animals such as meat, fat, urine, and blood for the treatment of acne, rabies, diabetes, and tumors.

Throughout the history of humanity, different cultures around the world have caught, kept, and bed animals as pets (Collar *et al*., 2007; Carrete & Tella, 2008). Nóbrega-Alves (2012) explain that native people frequently capture young animals of various kinds and rear them as domesticated animals. Among the most common species used as pets are parrots (Thomsen & Brautigam, 1991), coatis, and squirrels (Nóbrega-Alves, 2012), which were also the pets recorded in this study. The use of many wild species as pets has stimulated the trade of animals with consequential impacts on wild populations (Nóbrega-Alves 2012; Buenrostro-Silva *et al*., 2021). Deers and wild cats were the main species recorded with most commercial use in and around the natural protected area. People over 50 years (n = 22) argued that there is a decline in the population sizes and even the local extinction of some species, such as *Potos flavus* (Schreber, 1774), *P. onca*, and *Amazona finschi* (Sclater, 1864). They claimed that these animals have disappeared from the region, while in previous decades they were considered abundant.

Since prehistoric times, different animal products have been used by humans as ornaments and decorative materials (Pedersen, 2004). According to Nóbrega-Alves (2012), wild-animal-derived decorations and ornaments are often high-value luxury products and may be bought for adornment, fashion, or as part of traditional wear or for luck and prestige. In our study, the skin of *L. wiedii* is used as home decoration and deer antlers are used as trophies and placed as ornaments inside houses. A special case is the use of *D. novemcinctus* skin, which is a utilitarian object (seed-harvesting vessel) widely used in the coastal region of Oaxaca (Buenrostro-Silva *et al*., 2016).

The links that we found between use and harm may be helpful for the generation of management strategies for the conservation of species. For example, *O. virginanus* (whitetail deer) is related to use through its flesh, as a pet, and as adornment (antlers), but it is also considered a harmful species to crops, so the opportunity to use such species as an economic resource could be the alternative to hunting them (Mandujano, 2016). It should be mentioned that deer are not included in conservation status under Mexican national laws (Diario Oficial de la Federación, 2010).

The inhabitants of communities around the CNPA El Gavilán have extensive knowledge and make use of the wildlife, but there are differences in use among the species. Here we present a synthesis of the most relevant knowledge and uses of wildlife in communities around a natural protected area. In the case of wildlife conservation, it is evident that an understanding of the cultural, economic, social, and traditional roles played by animals is essential for establishing

management plans directed towards sustainable use. These results underscore the importance of ethnozoological studies to create meaningful animal conservation strategies (Nóbrega-Alves, 2012).

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