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Keywords: 2MX/Chiapas/conflict/diet/jaguar/*Panthera onca*/prey species/protected areas/status

Abstract: In Chiapas as in many parts of Mexico, the habitat loss resulting from diverse human activities, represents the main threat to the survival and conservation of jaguars. Species were distributed in almost the whole state of Chiapas, but at the moment it can be found in the main natural protected areas and the adjacent areas. For the communities, jaguars represents an enemy to their interests and patrimony because the real or perceived attacks to his cattle. During several decades, the Institute of Natural History and Ecology has been carrying out different studies and work with the species. These include distribution, abundance, habitat use, diet, ecto and endo parasites, microbiology, genetics and the conflicts man-jaguar. It has also studies on captive animals. The presence of some species of Nematodes, Cestodes and Protozoa, as well as different species of Bacteria has been documented. Results show that in the Sierra Madre de Chiapas the main prey species on the diet of this felid are, *Tayassu tajacu*, *Cuniculus paca* and *Tapirus bairdii*, followed by *Philander opossum*, *Tamandua mexicana* and *Nasua narica*; however, a total of 20 species have been confirmed to be part of their diet, including domestic animals, which represent 2.22% of 45 analyzed feces. Chiapas has over a million hectares of protected areas as Biosphere Reserves, where jaguars can be found, however, some of them are isolated and fragmented, which represents a threat for the long-term persistence and conservation of the species. For more than 9 years of study, on the presence and distribution of the species in the Sierra Madre, an abundance of 0.007 tracks/km has been obtained for El Triunfo and 0.013 track/km for La Sepultura. A very slight increase in abundance is suggested in the Sierra Madre; however, the pressures increasing.

# CURRENT STATUS OF JAGUARS IN CHIAPAS

EPIGMENIO CRUZ, GABRIELA PALACIOS, AND MARCELINO GÜIRIS

## Resumen

La pérdida de hábitat por las actividades humanas representa la mayor amenaza para la supervivencia y conservación del jaguar (*Panthera onca*) en Chiapas. La especie se distribuía en casi todo el estado de Chiapas, pero actualmente sólo persiste en las principales áreas naturales protegidas y zonas adyacentes. Para las comunidades de esa zona el jaguar representa un enemigo a sus intereses y patrimonio, por el ataque real o imaginario a los animales domésticos. Durante varias décadas el Instituto de Historia Natural y Ecología de Chiapas ha realizado estudios sobre la distribución, abundancia, uso de hábitat, hábitos alimentarios, parásitos, microbiología, genética, los conflictos hombre-jaguar, así como diferentes aspectos de la vida en cautiverio. Se ha documentado que en la Sierra Madre de Chiapas el jaguar consume más de 20 especies de las cuales los principales son el *Tayassu tajacu*, *Cuniculus paca*, *Tapirus bairdii*, *Philander opossum*, *Tamandua mexicana* y *Nasua narica*. Los animales domésticos representaron el 2% de 45 excretas analizadas. En Chiapas hay más de un millón de hectáreas de tierras protegidas como reservas de la biosfera en las que es posible encontrar al jaguar; sin embargo, en algunas de ellas la fragmentación y el aislamiento representan una seria amenaza para su permanencia y conservación a mediano plazo. Durante más de 9 años de registro de datos de la presencia y distribución de la especie, en la Sierra Madre se ha obtenido una abundancia de 0.007 rastros/km para El Triunfo y de 0.013 rastros/km para La Sepultura. Se aprecia una tendencia muy ligera al aumento de la abundancia en la Sierra Madre, sin embargo, las presiones son cada vez mayores.

Palabras clave: áreas naturales protegidas, conflicto humano-jaguar, hábitos alimenticios, especies presa.

## Abstract

*In Chiapas as in many parts of Mexico, the habitat loss resulting from diverse human activities, represents the main threat to the survival and conservation of jaguars. Species were distributed in almost the whole state of Chiapas, but at the moment it can be found in the main natural protected areas and the adjacent areas. For the communities, jaguars represents an enemy to their interests and patrimony because the real or perceived attacks to his cattle. During several decades, the Institute of Natural History and Ecology has been carrying out different studies and work with the species. These include distribution, abundance, habitat use, diet, ecto and endo parasites, microbiology, genetics and the conflicts*

*man-jaguar. It has also studies on captive animals. The presence of some species of Nematodes, Cestodes and Protozoa, as well as different species of Bacteria has been documented. Results show that in the Sierra Madre de Chiapas the main prey species on the diet of this felid are, Tayassu tajacu, Cuniculus paca and Tapirus bairdii, followed by Philander opossum, Tamandua mexicana and Nasua narica; however, a total of 20 species have been confirmed to be part of their diet, including domestic animals, which represent 2.22% of 45 analyzed feces. Chiapas has over a million hectares of protected areas as Biosphere Reserves, where jaguars can be found, however, some of them are isolated and fragmented, which represents a threat for the long-term persistence and conservation of the species. For more than 9 years of study, on the presence and distribution of the species in the Sierra Madre, an abundance of 0.007 tracks/km has been obtained for El Triunfo and 0.013 track/km for La Sepultura. A very slight increase in abundance is suggested in the Sierra Madre; however, the pressures increasing.*

*Key words: diet, human-jaguar conflict, natural protected areas, prey species.*

## **Introduction**

In Chiapas as in many parts of Mexico and Latin America, habitat loss, the expansion of the agricultural frontier and hunting are the main threats to the survival of jaguars. Forest fires destroy jaguar habitat every year; on average, 27,283 ha were lost every year between 1995 and 2002; the figure increased to 67,355 ha in 2003 (INEGI 2005). The jaguar used to be broadly distributed in practically all the habitat types of the state, from mangroves at sea level to cloud forests (Álvarez del Toro, 1977; Aranda and March, 1987). These habitats have suffered major changes which have pushed jaguars to find its last refuge in protected areas (Figure 1).

One of the aims of the Natural History and Ecology Institute of Chiapas (*Instituto de Historia Natural y Ecología de Chiapas*) is to explore the distribution, abundance, current status and problems of jaguars, as well as different biological, ecological and social aspects regarding the species in the state. To this end, the Institute has carried out various *in situ* and *ex situ* studies focused on reproductive aspects, diet, breeding, behavior, management and biomedical issues.

## **Methods**

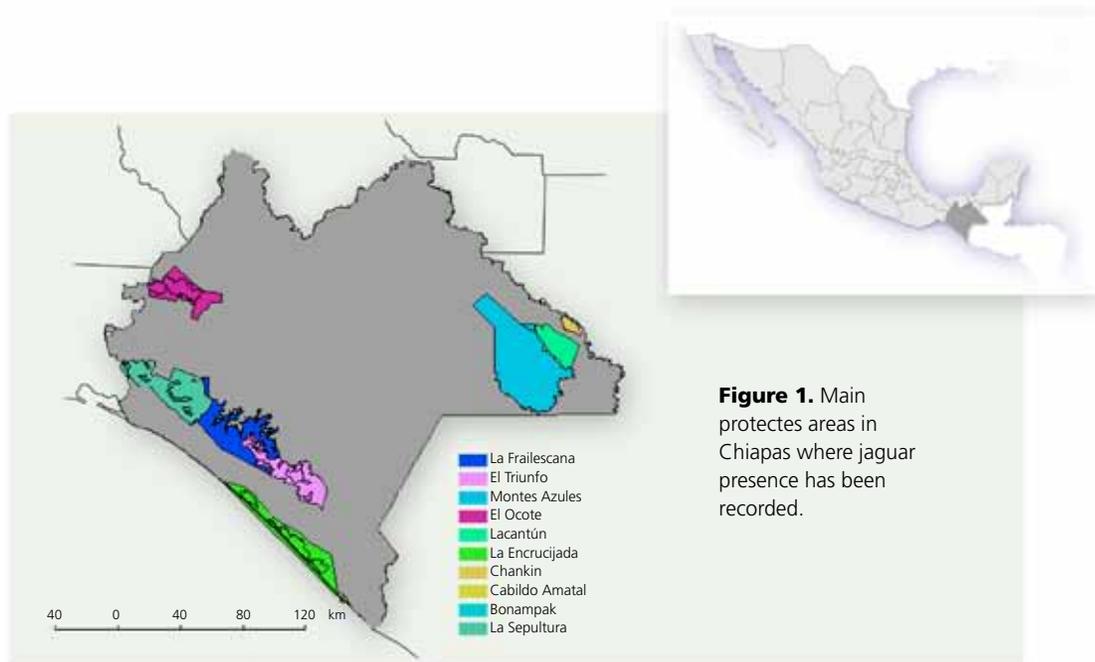
Captive jaguars in Miguel Álvarez del Toro Zoo (ZooMAT) were offered different species and parts of the same ones as food to determine what diet leads to good physical condition, a healthy looking coat, and a good reproductive condition. Jaguars were given live prey once a week. Scats were collected for parasitological and microbiological tests. A description and more details of the methods, procedures and tests can be found in Bastard (2003), Jiménez (2003) and Moreno (2003).

### *Ex situ*

Data for the study were collected over more than 9 years. Field visits involved monthly 8-to-10-day transect walks in El Triunfo and La Sepultura Biosphere Reserves, in the Sierra Madre de Chiapas. The transects had different lengths and widths. Work was divided into three parts:

a) *Fieldwork*: The transect walks took place in the morning and part of the afternoon (from 07:00 to 16:00-17:00 hr); all jaguar scats found were collected, and collection data were recorded. Other signs of jaguar presence –tracks, remains of prey and resting places– were also recorded, with a criterion confirming the truthfulness of records. The difference in scat diameter was also recorded, based on field experience.

b) *Laboratory work*: The scats were analyzed using the technique proposed by Korschgen (1948) and Chinchilla (1997) and modified by Cruz (2001) it consists of dehydrating or drying all the scats in the sun, weighing them in a top loading balance, and washing them in a bowl with running water. After this, a 12 to 20 thread mesh strainer was used to separate the larger contents of the scat and dry them at room temperature on absorbent paper. Once the strainer was dry, it was covered with a nylon stocking to collect the smaller components that remained in the bowl and continue the drying process. When this material was dry, the contents of each sample were separated based according to their structure –hair, claws, teeth, bones, feathers and plant material– for subsequent identification.



**Figure 1.** Main protected areas in Chiapas where jaguar presence has been recorded.

Items found in the samples were identified at ZooMAT with the support of the material held in the scientific collections of mammals and birds of the Natural History and Ecology Institute. The collection of hair and other bony structures (nails, claws, hoofs, skin, teeth and feathers, among others) deposited in the research unit at ZooMAT was also used.

d) Data analysis: Records obtained were included in a database with the following information: species, reserve, season (wet or dry), transect, type of habitat, and weight. A one-way analysis of variance (ANOVA) was conducted to compare species, areas, prey, and seasons (wet and dry) using Microsoft Excel. Habitat use and preference were obtained from the percentage area occupied by each type of habitat in the study area and the number of scats and other traces recorded, using Habuse 4.0 (Byers *et al.*, 1984).

We calculated the relative frequency of each of the prey species in the diet and estimated relative biomass using the following formulas (Chinchilla, 1997):

$$FA_i = \frac{\text{\# of samples in which prey } i \text{ was found}}{\text{total \# of samples}}$$

$$\text{BER} = \text{minimum \# of prey} \times \text{mean body weight of each specific trophic category}$$

The estimated weight of each prey was taken from the records of the database kept by ZooMAT.

## Results and discussion

The captive jaguars in the zoo were given horse, chicken, and rabbit meat, as well as some wild animals; they were fed live prey once a week to allow them to hunt, stay active and improve their digestion and bowel transit. The captive jaguars were in good condition, looked healthy and were considered fit for breeding.

The gastrointestinal parasites recorded in scats of captive and wild jaguars in Chiapas are shown below.

Nematodes: *Strongyloides* sp., *Toxocara cati*, *Toxocara mystax*, *Toxocara leonina*, *Uncinaria* sp., *Ancylostoma* sp., *Physaloptera* sp., *Capillaria aurophila* and *Capillaria* sp.; cestodes: *Taenia* sp., *Diphyllobothrium* sp. and *Paragonimus* sp.; protozoans: *Eimeria* sp., *Cryptosporidium* sp., *Isospora felis* and *Isospora rivolta*. On a microbiological level, bacterial species reported include *E. coli*, *Enterobacter cloacae*, *Proteus vulgaris*, *Kloivera* sp. and *Clebsiella* sp. (Bastard, 2003; Jiménez, 2003; Moreno, 2003).

### *In situ*

We analyzed different aspects of jaguar ecology, such as current distribution, abundance (Juárez, 2002), habitat use, feeding habits, parasites, microbiology, and human-jaguar conflicts. We also started population genetic studies based on scat analysis. Additionally, we explored the population ecology of the species in different sites of Chiapas –mainly protected areas– and areas that are not protected but whose vegetation is well preserved. Surveys of different parts of El Triunfo and La Sepultura have shown that jaguar populations are increasingly affected by human activities, such as hunting, crop and livestock farming, deforestation, fires and the development of new human settlements.

State government programs are proposing different alternatives to ‘improve the living conditions of communities’ at a high environmental price. Some imply clearing large areas of primary vegetation to grow forest species that occur naturally in the area. Others propose introducing domestic animals without any previous assessment, technical advice or appropriate support to ensure effective practices. Moreover, Chiapas has a constant movement of groups looking for land to settle in temporarily or permanently, which results in the clearing of large areas of primary vegetation that are of vital importance for the survival of jaguars.

### **Jaguars and their status in protected areas**

The presence of the jaguar in certain areas is specifically related to the presence of biosphere reserves, particularly the ones in the Selva Lacandona (412,910 ha) and several federal reserves such as El Ocote (101,288 ha), La Sepultura (167,309 ha), La Frailescana (181,350 ha), El Triunfo (119,177 ha) and La Encrucijada (144,868 ha). The total surface protected by these reserves is close to 1,126,903 hectares (Semarnat, 2005). The jaguar is present in these areas as well as adjoining ones with considerable plant cover and high human pressure. There are conflicts with jaguars around protected areas due to predation on domestic animals.

The areas covered with vegetation that can potentially maintain jaguar populations have different characteristics regarding protection priorities and conservation actions. The Selva Lacandona not only has excellent characteristics to maintain viable jaguar populations, but is also connected to the area of Los Petenes in Guatemala and the south east of Mexico. El Ocote Biosphere Reserve also has specific features that make it an area with the potential of maintaining viable jaguar populations; moreover, its jaguar populations are connected to those of Los Chimalapas in Oaxaca and Veracruz. The populations in the south and south west of the state must also be taken care of.

According to Palacios (2005), semi-evergreen forests, pine-oak forests, grasslands and cloud forests are of great importance in the habitat use and diet preference of jaguars in the Sierra Madre (Table 1).

**Table 1.** Observed and expected scat frequencies of *P. onca* by habitat type in La Sepultura Biosphere Reserve

Habitat	of <sup>1</sup>	ef <sup>2</sup>	Pof <sup>3</sup>	Pef <sup>4</sup>	Confidence interval <sup>5</sup>
Pine forest	8	6.603	25.80	10.52	0.056-0.460 (-)
Pine-oak forest	11	20.150	35.48	32.11	0.133-0.576 (*)
Pasture	2	13.144	6.45	10.27	0.000-0.178 (*)
Semi-evergreen forest	3	4.960	9.67	15.41	0.000-0.234 (-)
Semi-deciduous forest	7	17.887	22.58	35.98	0.032-0.419 (*)
<b>Total</b>	<b>31</b>	<b>62.744</b>	<b>100</b>	<b>100</b>	

<sup>1</sup> Observed frequencies.

(\*) Habitat used as expected

<sup>2</sup> Expected frequencies.

(-) Habitat used less than expected

<sup>3</sup> Proportion of obs. freq.

<sup>4</sup> Proportion of exp. freq.

<sup>5</sup> Bonferroni intervals ( $X^2=21.300$ ;  $gl=4$ ;  $P>0.05$ )

### Isolation of protected areas

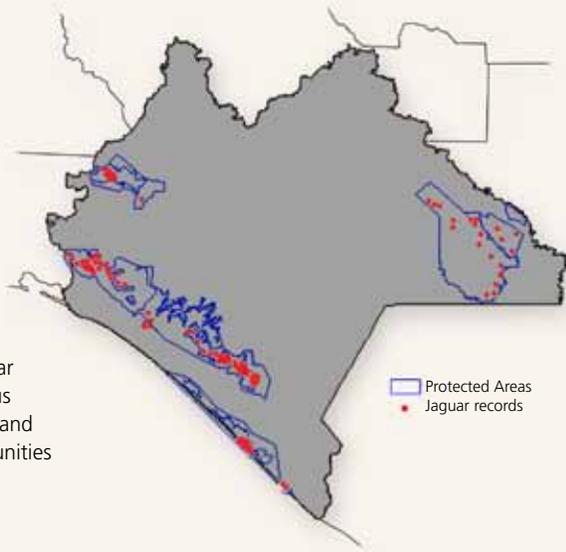
The protection of the Sierra Madre and the coastal plains of Chiapas is enough to maintain viable jaguar populations in the long term. In the reserves of La Sepultura, La Frailescana and El Triunfo, the only areas with suitable conditions for the jaguar are in the intermediate and higher parts of the Sierra (Carrillo *et al.*, this volume). La Encrucijada, in the coastal plain of Chiapas, is a fully protected area where jaguars can still be seen (Figure 1).

The presence of the species has been documented in different parts of the state through sightings, signs and predation on domestic animals (Figure 2). Records collected over more than 9 years report the presence of the species in the Sierra Madre de Chiapas. In five years of monitoring, particularly in El Triunfo, the relative abundance recorded was 0.007 signs/km in El Triunfo and 0.013 signs/km in La Sepultura. Jaguar populations seem to be experiencing a slight positive trend in the Sierra Madre in almost 10 years of monitoring (Figures 3 and 4).

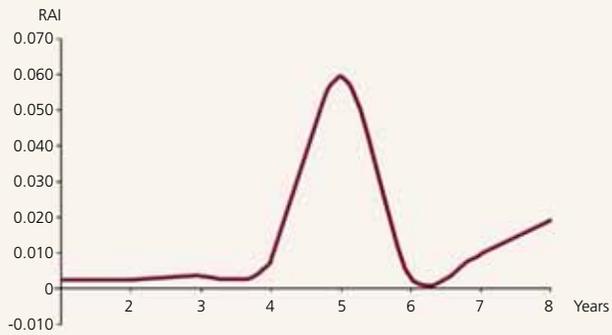
### Feeding habits

With the support of studies on the diet and feeding habits of jaguars, we recorded about 20 wild animal species in 45 scats analyzed (Table 2). They included the collared peccary (*Tayassu tajacu*), paca (*Cuniculus paca*), tapir (*Tapirus bairdii*), gray four-eyed opossum (*Philander opossum*), northern tamandua (*Tamandua mexicana*) and white-nosed coati (*Nasua narica*). The first three species were the most frequent, reaching similar levels to those reported by Chinchilla (1997). The analysis of species richness in the prey consumed suggests that the jaguar does not have a preferred species that forms the basis of its diet. These findings are similar to those reported by Mondolfi and Hoogesteijn (1986) and Crawshaw and Quigley (1991) in The Pantanal, Brazil, where the jaguar was found to consume larger prey.

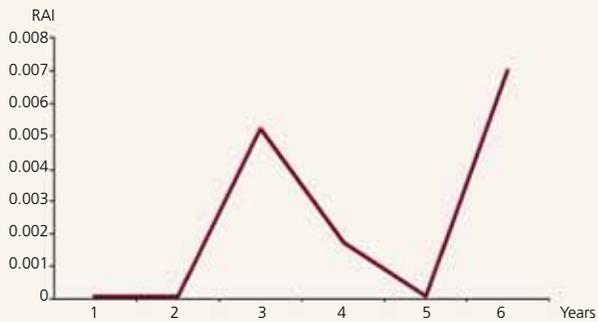
As for livestock predation, only 2.2% of the samples analyzed contained traces



**Figure 2.** Jaguar records in various protected areas and adjacent communities in Chiapas.



**Figures 3 and 4.** Behavior of jaguar abundance and trend shown by the population in the Sierra Madre de Chiapas in over 8 years of monitoring.



**Table 2.** Vertebrate species identified in jaguar diet and their relative frequency of occurrence in the Sierra Madre de Chiapas

Species	Frequency
<i>Cathartes aura</i>	0.02
<i>Caluromys derbianus</i>	0.02
<i>Didelphis virginiana</i>	0.02
<i>Philander opossum</i>	0.09
<i>Dasybus novemcinctus</i>	0.07
<i>Tamandua mexicana</i>	0.09
<i>Canis latrans</i>	0.02
<i>Bassariscus sumichrasti</i>	0.07
<i>Nasua narica</i>	0.09
<i>Tapirus bairdii</i>	0.11
<i>Tayassu tajacu</i>	0.27
<i>Mazama temama</i>	0.07
<i>Odocoileus virginianus</i>	0.07
<i>Sciurus depeii</i>	0.02
<i>Sciurus aureogaster</i>	0.02
<i>Cuniculus paca</i>	0.11
<i>Bos taurus</i> and <i>Bos indicus</i>	0.02
<i>Equus caballus</i>	0.02
Unidentified mammal	0.04
Unidentified rodent	0.02

of bovine and equine livestock (Palacios, 2005). These results prove that the jaguar does not have a direct or intense impact on domestic animals. However, the fact that puma and jaguar attacks on livestock are periodically reported seems contradictory. The results obtained in this study show that jaguars are not the only animal to blame for the death and loss of livestock; pumas also occur in these areas and may be responsible for some of these deaths (Palacios, 2005).

For 16 years, jaguars have been documented to kill an average of 18 livestock a year, which amounts to a total number of 295 animals (horses, sheep and cattle) in ejido Adolfo López Mateos, in Arriaga, La Sepultura Biosphere Reserve. Workshops have been organized to improve the relation of landowners with the jaguar and reduce conflicts. In La Sepultura, the damage seems to be relatively severe in at least three ejidos (López Mateos, Tierra y Libertad and Tiltepec), where jaguars and pumas are affecting the resources of local people. These communities have agreed to gradually replace their livestock operations by alternative options that contribute to jaguar conservation.

Even though it is still relatively easy to find jaguars in Chiapas, their distribution is increasingly restricted to high mountain areas. Governments, authorities, scholars and society must therefore join efforts both to conserve the species and to find a better way of life for rural communities. These efforts must combine and satisfy the interests of the species and the human populations to conserve jaguars in Chiapas and Mexico.

## **Perspectives**

This study provides important information about the threat human activities represent for the survival of jaguars in Chiapas and the threat posed by jaguars to the interests of human populations and their livestock. Our findings can be used to guide actions that protected areas, and governments must consider conserving the species and its habitat.

It is important to intensify and extend the sampling effort to a greater number of sites in Chiapas to document the current status of jaguars in the state, and implement other monitoring and marking methods. Existing issues between human and jaguars must be dealt with, taking claims into account and trying to find solutions or mitigation measures that reconcile human interests and jaguar conservation. Committees should be set up and involve, at least, representatives of society, scholars, conservation institutions and governments.

## **Acknowledgments**

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