Use of the paca, *Cuniculus paca* (Rodentia: Agoutidae) in the Sierra de Tabasco State Park, Mexico

Sonia Gallina[1], Jairo Pérez-Torres[2] & Carlos César Guzmán-Aguirre[3]

1. Red de Biología y Conservación de Vertebrados. Instituto de Ecología, A.C. Carretera Antigua a Coatepec #351, Las Hayas, C.P. 91070, Xalapa, Veracruz, México; sonia.gallina@inecol.edu.mx
2. Laboratorio de Ecología Funcional. Unidad de Ecología y Sistemática (UNESIS), Departamento de Biología. Pontificia Universidad Javeriana Cra. 7 No. 43-82. Bogotá, Colombia; jaiperez@javeriana.edu.co
3. Estudiante del Posgrado del Instituto de Ecología, A.C. Carretera Antigua a Coatepec #351, Las Hayas, C.P. 91070, Xalapa, Veracruz, México. Present address: Instituto de Neuroetología. Universidad Veracruzana; caguzman@uv.mx

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Abstract: *Cuniculus paca* is widely distributed throughout the Neotropics. Known as the paca, it is the largest rodent in the Mexican tropical forests, and one of the most used as a subsistence species for its meat. Since colonial times, this species has been subject of an unreported hunting pressure. For this reason, the aim of this work was to describe the use of the paca by the inhabitants of the Sierra de Tabasco State Park (STSP) using sampling areas in a matrix of vegetation with different degrees of disturbance, and different types of land use. We included both preserved areas: owing to the presence of large continuous areas of fragmented rainforest and areas that are not preserved, with smaller rainforest fragments and more isolated. To obtain information about paca use, we interviewed 176 people (>18 years old) who live in the STSP. All those interviewed had eaten paca meat, and indicated that this species is most frequently observed in the rainforest during the dry season. Hunting and trapping were the most common ways to obtain pacas, rather than gifting or purchasing, and firearms and dogs are used to hunt them. We estimated that these interviewed group had hunted a total of 488 paca in the year prior to the study. Rev. Biol. Trop. 60 (3): 1345-1355. Epub 2012 September 01.

Key words: dogs, firearms, hunting, interview, paca, preserved areas, rainforest, seasons, unpreserved areas.

Subsistence hunting, along with deforestation and the transformation of native rainforest are common activities in the Neotropics (Robinson & Redford 1991, Robinson & Bennett 2000), and have caused a considerable decrease in the populations of many species. In Mexico, subsistence hunting is an important source of protein for rural populations, particularly in the Southeastern part of the country. This kind of hunting is legal and therefore is not recorded or quantified. However, as populations expand they quickly transform and fragment tropical forests (Galetti *et al*. 2006), and the resulting pressure on wildlife is increasing.

In Tabasco, for example, the expansion of agriculture has resulted in a 90% decrease in high and medium rainforest relative to its original distribution (Tudela 1990). In response, the state government of Tabasco created the Sierra de Tabasco State Park (STSP) in 1988 as part of the System of Protected Natural Areas of the state of Tabasco. This park was created to protect the high and medium rainforests still present in the region, though within the reserve there are crops and areas with secondary vegetation (Periódico Oficial del Estado de Tabasco 1988). Subsistence hunting is practiced in rural communities, and the paca is one of the most hunted species as it is the meatiest (De la Cruz-Felix 2008).

Cuniculus paca is widely distributed throughout the Neotropics and its delicious, tender meat is greatly enjoyed throughout its range (Pérez 1992). This species is found in

Mesoamerica and South America in Guatemala, Belize, Panama, Colombia, Venezuela, Trinidad, Guiana, Brazil, and from Peru to Paraguay and Northern Argentina, which is the Southern limit of its distribution (Matamoros 1985, Eisenberg 1989, Pérez 1992). In Mexico it is distributed from the Southern part of the state of Tamaulipas down through San Luis Potosí, Veracruz and Tabasco, and Eastwards in the Yucatan Peninsula. On the Pacific coast, it occurs from the state of Guerrero, through Oaxaca to Chiapas (Aranda 2000).

Owing to its broad distribution, the paca has many other common names. In Central America it is called "gibnut" or "gibnot" (Belize), "tepezcuintle" (Guatemala and Costa Rica), "conejo pintado" (Panamá). In South America it is known as "lapa" (Venezuela and Colombia), "borugo", "guagua", "tinajo", "guartinajo" (Colombia), "lape" and "majaz" (Perú), "paca" (Brazil) and "Guanta" o "lumucha" (Ecuador); "jochi pintado" (Bolivia). In Mexico it is called "tepezcuintle", "guatuza real", "tuza real" or "perro de monte" (Smythe & Brown de Guanti 1995, Pérez-Torres 1996) and in English it is known as the paca.

Cuniculus paca (Linnaeus 1766) inhabits dry forests, rainforests, and mangroves, and is generally found near rivers, lagoons and ravines (Matamoros 1982). This species is mainly frugivorous and eats a wide variety of wild and cultivated fruit, though it also eats seeds and plant material, including sprouts, roots, tubers, bulbs, rhizomes, leaves and herbs (Borrero 1967, Méndez 1970, Leopold 1977, Matamoros 1985). Its territory spans two to three ha, and its population density varies throughout the year, depending on local fruit production (Smythe 1983). The male and the female live in separate burrows, at opposite ends of the territory, allowing them to defend their turf together.

For Mexico there is little information about pacas under natural conditions. The available information is mainly about burrow characteristics, ectoparasites, and feeding habits (based on fecal analysis to determine the composition and preference; Gallina 1981). For pacas in captivity, there have been studies on burrow preferences and behavior (Aguirre & Fey 1981), and there is information about sexing and marking the animals, and also about management with the aim of breeding pacas in captivity (Aguirre & Fey 1981). Reproductive activity has been described during puberty and postpartum, as has postpartum ovarian activity (Montes 2001).

Medellín (1994) reported that *C. paca* is vulnerable to the processes associated with forest fragmentation in the Lacandona rainforest in the state of Chiapas, Mexico and that this species is threatened owing to its habitat specialization (Rodríguez 1994).

The paca is the largest rodent in Mexican tropical forests, and is one of the most used as a subsistence species because of its meat. By way of example, compared to all species hunted in the Lacandona rainforest, the annual extraction rate of paca was reported as the highest, at 0.49 individuals/km^2/year (Guerra & Naranjo 2003). However, the degree of hunting pressure on this species is still not known for many protected areas. This way, our goal was to document the extent to which the inhabitants of the STSP and its surroundings, use *C. paca,* by comparing information from preserved and non preserved areas, and to obtain information that would allow us to propose suitable management and conservation strategies, for the sustainable use of this species within the protected area.

MATERIALS AND METHODS

Location of the study area: The state park is located in the subregion of the Sierra de Tabasco Mountain Range, in the Usumacinta region (17º 25' - 17º 40' N y 92º 37' - 92º 52' W) of the Tabasco State. It has an area of 15 113.2 ha and covers 5.98% of the state's land surface (SEDESPA 2004). The climate is warm-subhumid with rain throughout the year (AF), and thermal changes in October, November and December. Mean annual temperature is 25.6°C, with a mean monthly maximum of 29.2°C in May, and a mean monthly minimum of 22°C in December. This is the rainiest part of

the country and one of the four rainiest regions in the world: precipitation is 3 515-5 139mm/year. Maximum mean relative humidity is approximately 95% in the wet season (September, October and November) and the minimum is 78% in the dry season (March, April and May; INEGI 1998).

There are several types of vegetation in the region, including tropical evergreen forest that ranges from 15-35m tall and different stages of secondary vegetation. In the three types of rainforest the vegetation is composed of arboreal species such as: *Pouteria zapota*, *Manilkara zapota*, *Pterocarpus rohrii*, *Platimiscyum yucatanum*, *Sterculia mexicana*, *Brosimum alicastrum*, *Guarea bijuga* and *Spondias mombin*; and species of palm such as: *Astrocarium mexicanum*, *Chamaedorea tepejilote* and *Reinhardtia gracilis* (SEDESPA 2004, De la Cruz-Félix 2008). The secondary vegetation is characterized by *Cecropia obtusifolia*, *Cochlospermum vitifolium*, *Cestrum nocturnum*, *Hampea integerrima*, *Hibiscus tiliaceus*, *Piper auritum* and *Heliconia bihai* (SEDESPA 2004, De la Cruz-Félix 2008). The most representative crops in the area are corn (*Zea mays*), beans (*Phaseolus vulgaris*), bananas (*Musa paradisiaca*), cacao (*Theobroma cacao*), coffee (*Coffea arabica*), pineapple (*Ananas comosus*) and habanero chilli peppers (*Capsicum* sp.). Grasses, such as *Cynodon plectostachium* and *Brachiaria humidicola*, are also grown (SEDESPA 2004).

Field work: One prospective and three preliminary pre-sampling expeditions were made from September-December 2005, along with four sampling expeditions from February-May 2006. Each trip lasted approximately 10 days. Using a geographic information system (GIS) and based on the vegetation degree of disturbance, we classified the STSP and surroundings as preserved (i.e. with a continuous rainforest area) and unpreserved (i.e. characterized by patches of rainforest that were much more fragmented and smaller); though in the preserved areas there were also different degrees of disturbance. Four preserved areas and four unpreserved areas were defined using a geographic information system based on the size of the patches of the rain forest (Fig. 1). Eight different sites were visited in the preserved areas and eight in the unpreserved areas to carry out the interviews.

Interviewing the local inhabitants: To determine the hunting pressure exerted on *C. paca* by the local communities in the STSP and its surroundings, 16 of the 24 communities (67%) within the reserve were visited and interviewed (Guerra & Naranjo 2003). This method has been widely used in the study of several species and is especially effective for those that are commonly hunted and observed by the local inhabitants (Lawes *et al.* 2000, Michalski & Peres 2005, Urquiza-Haas *et al.* 2009).

One hundred and seventy-six of the inhabitants over 18 years of age, and who carry out some kind of activity in the field, were interviewed by direct questioning (see the Appendix). The results were compared between the eight communities in the preserved areas and the eight communities in the unpreserved areas. To analyze the results of the interviews we used Wilcoxon's paired samples test, Cochran's Q or McNemar's test as appropriate, to determine whether there were significant differences among the categories of answers to each question (Zar 1996). When Cochran's Q detected a significant difference Marascuilo and McSweeney's multiple comparison test (1967) with Scheffé's S statistic was used (Zar 1996).

RESULTS

In table 1 the total surface area and percentage of each vegetation type (crops, secondary vegetation and tropical rainforest) in the eight sample sites (four in preserved and four in unpreserved areas) in Sierra de Tabasco State Park, Mexico are shown in order to highlight the habitat fragmentation of the study area.

The results of the 176 interviews revealed that 100% of the people interviewed said they knew of and had eaten paca, both in the preserved and unpreserved areas. There were significant differences in the number of times *C.*

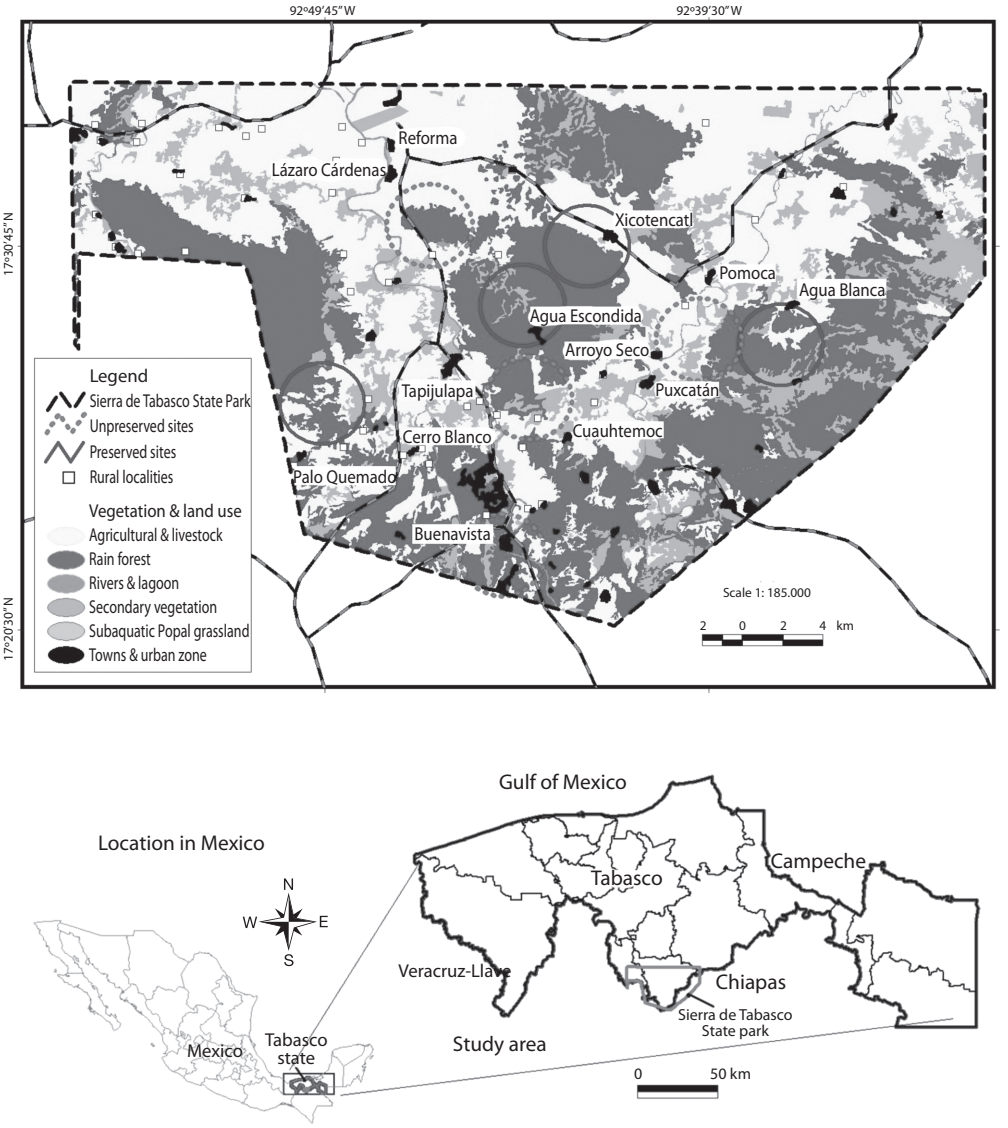

Fig. 1. Sampling site locations in the Sierra de Tabasco State Park, Mexico and its surroundings.

TABLE 1
Total surface area and percentages of each vegetation type in the eight sample sites (four in preserved and four in unpreserved areas) in Sierra de Tabasco State Park, Mexico

Vegetation type	Preserved	Unpreserved
Crops	1 349.55 ha (25.64%)	2 057.90 ha (41.37%)
Secondary Vegetation	477.84 ha (9.08%)	2 221.75 ha (44.67%)
Tropical Rainforest	3 436.74 ha (65.28%)	694.51 ha (13.96%)
TOTAL	5 264.13 ha	4 974.16 ha

paca was observed between seasons and for different vegetation types (Cochran's Q, $p<0.01$) with the animal being sighted more often in the dry season and in the rainforest (Fig. 2).

When studying the methods, hunting and trapping were prevalent in both preserved and unpreserved areas, more so than gifting or buying pacas in terms of their frequency as a method of obtaining the animals. In the preserved and the unpreserved areas, Cochran's Q rejected the hypothesis that there are no differences in the methods used to obtain pacas ($p<0.01$). Hunting and trapping were significantly more common (75%) than gifting and purchasing. McNemar's test indicated that pacas are acquired significantly ($p<0.01$) more frequently (98%) for personal consumption than to sell.

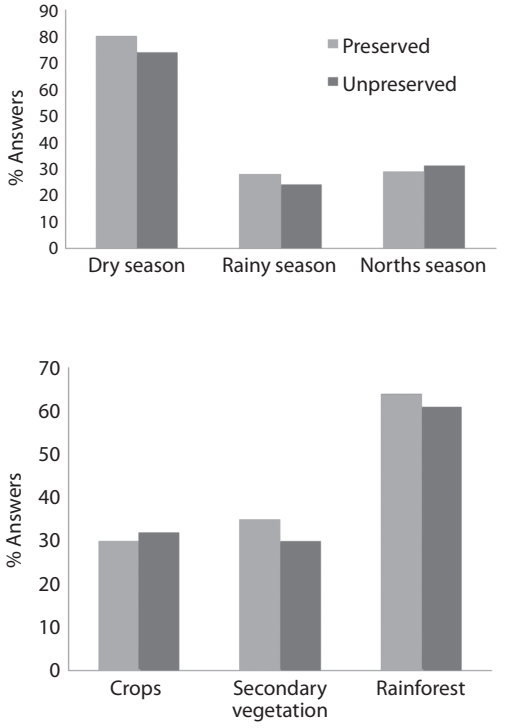

Fig. 2. Percentage of local people (N=176) who have seen the paca in different seasons (Answer to: when do you see pacas?) (A), and in different vegetation types (Answer to: where do you see pacas?) (B), in the preserved and unpreserved areas in the Sierra de Tabasco State Park, Mexico.

On analyzing whether the interviewees felt that the paca is abundant in the ejidos, McNemar's test revealed a significant difference ($p<0.01$) between the answers "yes" and "no" for both the preserved and unpreserved study areas (Fig. 3).

There was a significant difference in the techniques used by the inhabitants for hunting the paca ($p<0.01$). Dogs (50%) and firearms (60%) are the most commonly used aids for hunting ($p<0.05$), and are particularly evident in the unpreserved areas. Trapping is the less used technique (25%).

Recall that a total of 16 communities were visited. The number of pacas hunted per year differs between the preserved and unpreserved areas and 1-3, 4-6 and 7-9 animals are hunted per year per person, with 1-3 pacas per person the predominant number (Fig. 4). The minimum number of each interval was multiplied by the total number of people interviewed, to obtain a total of 488 paca hunted/year. That means that if we use the mean weight of 7.3kg/paca (Guerra & Naranjo 2003) this is the equivalent of 3 562kg of paca being caught. This is different from other sites where extraction estimates are 173 (Caquetá, Colombia; Rodríguez & Van Der Hammen 2003), 271 (the Lacandona rainforest, Chiapas; Guerra & Naranjo 2003) and 799 (Pasco, Perú; González 2003) pacas per year.

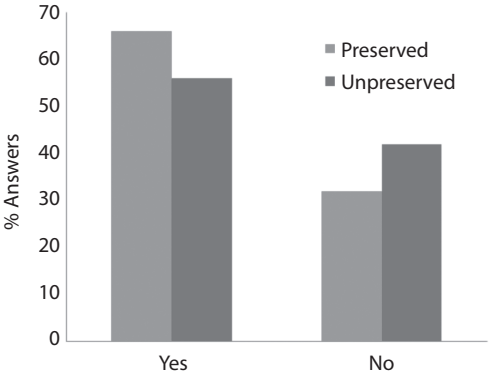

Fig. 3. Percent perceived abundance of the paca in preserved and unpreserved areas in the Sierra de Tabasco State Park, Mexico, according to the interviewees (Answer to: Do you think pacas are abundant in the ejido?) (N=176).

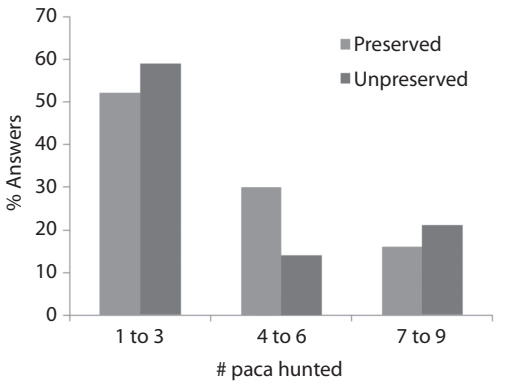

Fig. 4. Number of pacas hunted per year by the *ejidatarios* of the Sierra de Tabasco State Park, Mexico and surrounding areas (N=176).

DISCUSSION

From pre-Colombian times the paca has been used as a food source obtained by subsistence hunting (Ojasti 1993). Its meat is still eaten in the communities located in the study area since all those interviewed know of and have eaten this animal. The rate of extraction in the study area was estimated to be 488 pacas per year, and this is among the highest values recorded for other localities: Caquetá, Colombia (173; Rodríguez & Van Der Hammen 2003); the Lacandona rainforest, Chiapas, Mexico (271; Guerra & Naranjo 2003) and Pasco, Peru (799; González 2003).

Hunting in the study area has provided a complementary source of animal protein. Eighty percent of the people interviewed hunt the paca for food (98%). This concurs with the findings of Guerra & Naranjo (2003) for two sites in the Lacandona rainforest in Chiapas, Mexico, where they mention that subsistence hunting is a complementary activity since they met no one who spends all of their time hunting wildlife, because it cannot provide the same income as that generated by cattle ranching, trading or agriculture. This is similar to the findings of our study.

Many species are affected by hunting to a greater extent than they are by deforestation (Bodmer 1994). The rural inhabitants of the Neotropics mainly hunt for subsistence or to sell the meat and fur in city markets. This is why implementing sustainable hunting practices is a complex process that must take into account the socio-economic status of the rural inhabitants, the biology of the species, institutional capacity and national and global economic pressure (Bodmer 2003). In the STSP and its surroundings, there is no sustainable management, and nule control on hunting. This highlights the importance of implementing Units for Management (known as UMAs, for their initials in Spanish) to oversee intensive and extensive management, and protect species such as *Cuniculus paca* and other wildlife populations.

Attempts in the STSP and surrounding areas to set up captive breeding programs for the paca have been scarce. Only two percent of the inhabitants we interviewed have tried to raise this species. This may reflect the cultural hunting tradition of the inhabitants since selling the meat and fur of this species, is not considered a viable commercial endeavor. Because of this, there is a fair amount of pressure on the paca populations, which could exhaust this resource in the medium term.

Although, the paca has been found to be vulnerable to the processes of habitat fragmentation (Rodriguez 1994), given that it prefers forest, there is evidence that it is tolerant to habitat modification as shown in this study, where pacas were associated with secondary vegetation and crops. This has also been reported for similar species such as agoutis (*Dasyprocta* spp.) and the armadillo (*Dasypus novemcinctus*), both of which are associated with vegetation mosaics composed of near climax primary rainforest, mature secondary vegetation, crop fields and pastures (Brack 1981). This type of landscape configuration is characteristic of the Sierra de Tabasco State Park and its surroundings, and suggests that the paca is likely to encounter suitable habitats for feeding, refuge and breeding. Therefore, it would be possible to develop management plans for

this species by protecting those areas within the landscape mosaic that favor the species.

Preserving the sites that ensure access to water could favor the continued presence of this species in the region. The local inhabitants see this species most frequently (80%) during the dry season, in both preserved and unpreserved areas. This occurs, because when water availability is limited, the animals spend more time around water troughs, ponds and perennial springs, and at sites where a variety of plants are fruiting (Yockteng 1982). Hunters take advantage of this, due to the ease with which they can capture the pacas under these conditions. Additionally, in the context of setting up breeding programs, this would also be the best time to capture the animals to set up the founding colony. The importance of these preserved areas is evident given that it is there that the inhabitants report the greatest number of sightings of this species.

There is no difference in the methods used to hunt pacas and those used to hunt the other fauna of the region. The significant increase in the use of firearms is not particular to this region, but rather is occurring throughout the rural areas of the Neotropics. In Mexico, as in other countries, the introduction of modern agricultural tools and practices has resulted in the loss of traditional practices. This has occurred in the Lacandona rainforest in Chiapas (Guerra & Naranjo 2003) and in other countries such as Peru, where 90% of the inhabitants of the Yanesha Communal Reserve in Pasco use firearms (González 2003). This is detrimental to many species because, for example, it has been estimated that with firearms as many as 10 pacas can be caught in one day (González 2003). Trapping is a nonselective traditional method and is used to a lesser extent in the three locations mentioned above. Dogs were also commonly used; mainly to locate the burrows and then to get the pacas to leave. It is not common for pacas to be bred in Mexico or in Latin America. The most recent studies to report captive breeding experiments are those of Smythe & Brown de Guanti (1995) and Barrera & González (1999). These authors state that breeding this species is difficult owing to its low reproduction rate and the high cost of facilities. This was evident in our study area given that only 2% of the interviewees said they had tried to breed pacas, unsuccessfully, and that was why they continued hunting the wild populations in the forest directly.

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RESUMEN

Cuniculus paca está ampliamente distribuido en el Neotrópico. El tepezcuintle o paca es el roedor más grande que se encuentra en las selvas tropicales de México. En cuanto a la cacería de subsistencia es una de las especies más buscadas por su carne. Como se desconoce el impacto de esta actividad, se describe el aprovechamiento que le dan las comunidades humanas en el Parque Estatal de la Sierra de Tabasco (PEST). También, se determinaron zonas de muestreo, las cuales se encontraban en una matriz perturbada en menor o mayor grado, con diferentes tipos de uso de suelo. Además, se consideraron zonas conservadas por la presencia continua de grandes extensiones de selvas fragmentadas y las zonas no conservadas por tener fragmentos menores de selvas y estar más aisladas. Para conocer el aprovechamiento que se le da al tepezcuintle se realizaron 176 encuestas a campesinos o pobladores del PEST mayores de 18 años. El 100% de las personas encuestadas dijo conocer al tepezcuintle y haberlo consumido. La sequía fue la época en que significativamente se le observó más en la selva. Las formas de obtención del tepezcuintle que prevalecen son la cacería y el trampeo en contraste con la donación y la compra. Por otro lado, también utilizan armas de fuego y perros para su cacería. Consecuentemente, se estimó que las personas entrevistadas cazaron un total de 488 tepezcuintles en el año.

Palabras clave: entrevista, cacería, armas de fuego, perros, épocas, selva, tepezcuintle, zonas conservadas, zonas no conservadas.

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APPENDIX

Questionnaire used to interview the local inhabitants on their knowledge, hunting and use of paca

Community _____

Interviewer's Name _____

Date _____

Assistant _____

1. PERSONAL DATA

Name _____

Age _____

Marital status _____

How long have you lived here? _____

Birthplace _____

Occupation _____

Do other people depend on you?

Yes _____ How many? _____ No. / Family _____ No _____

Do you know how to read and write? Yes _____ No _____

Highest educational degree _____

2. PACA STATUS AND ECOLOGY

Do you know what a paca is? Yes _____ No _____

How often do you see pacas?

Yes _____ Never _____ Rarely _____

When (season) do you see pacas?

Dry season _____ Rainy season _____ Nortes season _____

When you saw a paca what was the date and was it… ? Date _____

With young _____ Adult _____

Alone _____ Cub _____ In a group _____

What kind of vegetation have you seen them in?

Rainforest _____ Secondary vegetation _____ Crop _____

Do you think pacas are abundant?

Yes _____ No _____

Where there are fewer?

Rainforest _____ Secondary vegetation _____ Crop _____

How long has it been since you saw a paca? _____

3. USE

Have you ever eaten paca?

Yes _____ No _____ Rarely _____

How do you prepare it? _____

How did you get it?

It was given to me _____ I bought it _____ By hunting _____ By trapping _____

What parts do you use?

Skin _____ Meat _____ Bones _____ Other _____

Where do you usually hunt?

Rainforest _____ Secondary vegetation _____ Crop

How do you hunt paca?

FIREARM

Shotgun _____ Gun _____ Rifle

TRAPPING

Net _____ Well _____ Snare

OTHER

Dogs _____

How many pacas do you catch…?

In a week _____ Month _____ Year _____

Do you have a preferred place for hunting?

Rainforest _____ Secondary vegetation _____ Crop _____

When do you capture pacas?

Dry season _____ Rainy season _____ Nortes season _____

At what time of the day?

Sunrise _____ Noon _____ Sunset _____ Midnight _____

How old are the paca you catch?

Adult _____ Young _____

How would you qualify your hunting success?

Low _____ Moderate _____ High _____

Hunters are.

Local people _____ Foreign people _____

Why do you hunt paca?

Pets _____ For sale _____ Subsistence _____

How much does the animal cost?

Per kg _____ Live _____ Carcass _____ Skin _____

Have you ever bred pacas in captivity?

Yes _____ No _____

Did the young survive?

Yes _____ No _____

Have you ever had problems with pacas in your crops?

Yes _____ Why? _____ No _____

What crops do you grow? _____