FIRST NATIONAL JAGUAR SURVEY

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Resumen

Las prioridades de conservación de especies que tienen grandes áreas de actividad, como los jaguares, deben de planearse a diferentes escalas (local a geográfica), además de tomar en cuenta el tamaño del área de actividad, el área de distribución y los distintos hábitat, y sus posibles interacciones con las actividades humanas. El Censo Nacional del Jaguar y sus Presas (CENJAGUAR), pretende realizar una estimación del jaguar y sus presas en sitios prioritarios para su conservación. Para ello se usará la técnica de trampas-cámara, que ha sido ampliamente usada para estimar las poblaciones de jaguar y también las abundancias de sus presas. Se recomienda una densidad de tres estaciones de muestreo por cada 9 a 16 km^2 para el jaguar y sus presas con grandes áreas de actividad. Para las presas con áreas de actividad pequeña se recomiendan nueve estaciones en 0.2 km^2. Se recomienda el uso de modelos de captura-recaptura para analizar los aspectos demográficos; sin embargo, se deben considerar aspectos como el tamaño de la muestra para generar una estimación estadísticamente robusta de densidad. El CENJAGUAR es el primer esfuerzo para llevar a cabo una evaluación de su situación poblacional a nivel nacional en México. No se han realizado estudios similares de esta magnitud en ningún otro país donde habita el jaguar. En este sentido, el proyecto marcará nuevos estándares para la conservación de la especie a nivel mundial. Esta información servirá para determinar las áreas prioritarias para la conservación del jaguar a escala local (ejidos), regional (nivel estatal) y geográfica (nivel país). La estrategia identificará las áreas que deben tener un manejo compatible con la conservación del jaguar y sitios adecuados para establecer corredores biológicos que una a los sitios prioritarios.

Palabras clave: censo nacional, estimación poblacional, presas, trampas-cámara.

Abstract

The priorities of conservation of species that have large home ranges, as the jaguars, have to of be planned at different scales, besides bearing in mind the size of the area of activity, the distribution area and different habitat, and his possible interactions with the human activities. The National Census of the Jaguar and its Preys (CENJAGUAR) will estimate the population status of jaguar and its preys in priority sites for his conservation. Cameras-traps, which have been widely used to estimate the populations of jaguars, will be used to estimate abundances. A density of three sampling stations for every 9 to 16 km^2 for jaguars

and preys with big areas of activity, whereas, for the preys with areas of small activity nine stations in 0.2 km^2. We recommend, the models' use of capture re-captures to analyze the demographic aspects; nevertheless, we must consider aspects to be the size of the sample to generate a statistically robust estimation of density, by what the use of indexes of abundance can be adapted, provided that the design this one standardized. The CENJAGUAR is the first effort to carry out an evaluation of his population national situation. There have not been realized similar studies of this magnitude in any other country where he inhabits the jaguar. In this respect, the project will mark new standards for the conservation of the species worldwide. This information will serve to determine the priority areas for the conservation of the jaguar to local scale (common lands), regional (state level) and geographical (level country). The strategy will identify the areas that must have a managing compatible with the conservation of the jaguar and sites adapted to establish biological corridors that one to the priority sites

Keywords: National census, population estimate, prey, camera-traps.

Introduction

Most populations of large carnivores are threatened or endangered due to anthropogenic factors (Treves and Karanth, 2003; Woodroffe and Ginsberg, 1998). Although the jaguar (*Panthera onca*) is broadly distributed species, it has lost more than half of its historical range because of habitat destruction and fragmentation, illegal hunting, a decline in its prey, and exotic diseases (Ceballos *et al*., 2002; Chávez, 2006; Chávez *et al*., this volume; Sanderson *et al*., 2002).

The jaguar is endangered in Mexico; yet, there has not been a thorough and updated assessment on the status of its populations to be able to design appropriate strategies for its conservation (Ceballos *et al*., 2006). The status of the jaguar and its population size have never been determined simultaneously in a whole country. The 2nd Symposium "The Mexican Jaguar in the 21st Century: Current Status and Management" was held in 2006. It brought together about 50 experts from universities, social organizations, the federal government and the private sector. One of the conclusions of the symposium was the need to implement specific actions on a national scale to reduce the extinction risk of the jaguar. The findings obtained in the symposium are the basis of a strategy for the long-term conservation of the species with objectives, targets and specific actions, including the preparation of a national survey (Ramírez and Oropeza, this volume).

The objectives of the first National Survey of the Jaguar and its Prey (CENJAGUAR) are to assess the population density of the jaguar and its prey in Mexico, determine jaguar habitat available in Mexico, and identify conservation requirements of the jaguar and its prey in priority areas. It aims at assessing the distribution and population status of the species in areas where it is currently uncertain whether the jaguar occurs or its populations are stable, whether there is suitable habitat and

enough prey for the species to survive, and in places previously identified as priority areas (Ceballos *et al.*, 2006; Chávez and Ceballos, 2006; Zarza *et al.*, this volume).

CENJAGUAR involves monitoring jaguar and prey populations and jaguar habitat at a large scale. It is therefore necessary to use a relatively easy and reliable method so that demographic data can be standardized. If the study persists in the long term, it will be possible to assess habitat and population viability on a regular basis. If this effort is made in parallel to other actions, such as those dealing with conflicts with livestock, it will lead to better understanding of human-jaguar relations. Along with national programs, such as Proarbol, UMAs (Wildlife Management Units) and the promotion of jaguar habitat and prey conservation, this kind of actions will lead to a better quality of life for local people.

Standardized protocol

In an attempt to standardize sampling designs, Silver *et al.* (2004) and Medellín *et al.* (2006) published two protocols to study the jaguar based on methods originally used to study tigers (*Panthera tigris*) in India by means of capture-recapture procedures (Karanth, 1995; Karanth and Nichols, 1998; 2002; Lynam, 2002).

The first protocol focuses on the use of camera traps in sampling to estimate jaguar abundance; it uses established capture-recapture procedures to analyze closed populations and spot patterns to identify individuals photographed. The date is printed in every photograph, which makes it possible to measure days or other units of time as discrete sampling events. This protocol has been used successfully to estimate the abundance of the jaguar and its prey (Maffei *et al.*, 2004; Silver *et al.*, 2004; Weckel *et al.*, 2006). In Mexico, it has been used in vegetation types as diverse as cactus scrub, tropical deciduous forest, semi-evergreen forest and tropical rainforest (Azuara, 2005; Azuara and Medellín, this volume; Ceballos *et al.*, 2005; López-González and Brown, 2002; Núñez *et al.*, 2000).

The second protocol was specifically developed for Mexico (Medellín *et al.*, 2006). It is the result of the working group on surveys and monitoring in the 1st Symposium "The Mexican Jaguar in the 21st Century: Current Status and Management" held in Cuernavaca, Morelos (Chávez and Ceballos, 2006). It estimates abundance using different methods: 1) search for sign, including tracks, 2) use of camera traps 3) scats and genetic analysis in the laboratory and 4) capture and radio telemetry.

National survey of the jaguar and its prey

This is the first effort to carry out a country-wide assessment of the status of the jaguar. No similar studies of this scale have been carried out in any of the other range countries of the jaguar. The project will set new standards for the conservation of the species worldwide. This information will be used to determine priority areas for jaguar conservation on a local (ejidos), regional (states) and national (country)

level. The strategy will identify areas whose management must be compatible with jaguar conservation and suitable places to establish biological corridors connecting priority areas.

Design of the survey

The design of the survey must involve a preliminary assessment of jaguar presence-absence in predetermined areas. Regional and national assessments are based on priority areas for jaguar conservation (Table 1; Ceballos *et al*., 2006). It is necessary to hold previous meetings with any organizations that might be interested in participating in the process. It is also important to obtain surveys with basic information about socioeconomic conditions and knowledge about wild animals in general and the jaguar and its prey in particular. This must be verified in the field to corroborate the presence of jaguars. Finally, results should be standardized qualitatively and quantitatively. The basis for this work will be the assessment suggested by Medellín *et al*. (2006), which includes all the necessary tools to conduct the assessment.

The existence of a population or individuals must be verified. This will be done by looking for tracks and other sign and using camera traps. When using camera traps, it is important to take certain issues into account to develop correct estimates (Karanth and Nichols, 2002). The survey is based on the use of camera traps, the safest and most viable method to obtain the necessary information on jaguar abundance and density throughout its range in different habitat types (Karanth and Nichols, 1998; Lynam, 2002; Medellín *et al*., 2006). For the purposes of this survey, a sampling station consists of one or two camera traps placed in one site. A sampling cell is the minimum home range of a female (9 km^2) in a certain amount of time, 20 days for practical and assessment purposes.

The following considerations must be taken into account regarding the design of CENJAGUAR:

1. All the individuals in a sampling area have the same probability of being captured –i.e., photographed– by one or more camera stations during the study. The design of the study must ensure that there are no gaps in the study area, to avoid situations in which an individual can move in its home range with no probability of being photographed. In each sampling cell, camera traps can be strategically placed to maximize capture probability, e.g., near scratching, tracks, scats, along hunting trails and near bodies of water.

2. Sampling time and duration shall be determined according to seasonal climatic conditions and access to the sampling area. In most areas (Table 1) this kind of study can be carried out in the dry season (January-May). However, this has to be defined with each researcher on the basis of seasonal considerations, accessibility and knowledge of the demographic parameters of the area or similar areas. Camera trapping can take 20 to 90 consecutive days. A sampling period exceeding 90 consecutive days may lead to violating the closed population assumption (Karanth and

Nichols, 1998). Although there are few data available on the natural history of the jaguar, accumulation curves for new individuals in tropical environments show that it takes about 20 days on average to obtain jaguar photographs in a sampling station (C. Chávez, unpublished data). Cameras must be checked every 10 days, and camera trap placement and removal must not be counted in the sampling effort.

3. Sampling effort will depend on the area. In rugged areas, it will take 5 to 10 days to place the camera traps and 4 to 8 days to remove them. Two to three camera

Table 1. Regions and states where CENJAGUAR will be conducted in Mexico

Region	State	Name	Institution/Organization
North	Sinaloa	Yamel Rubio	Universidad Autónoma de Sinaloa
North	Sonora	Gerardo Carreón	Naturalia A.C.
North	Sonora	Oscar Moctezuma	Naturalia A.C.
North	Sonora	Carlos Lopéz	Universidad de Querétaro
North	Sonora	Octavio C. Rosas Rosas	Colegio de Posgraduados, Unidad San Luis Potosí
North	San Luis Potosí	Octavio C. Rosas Rosas	
North	Tamaulipas	Arturo Caso Aguilar	Proyecto Felinos de México A.C.
Central Pacific	Jalisco	Rodrigo Núñez Pérez	Fundación Ecológica de Cuixmala A.C.
Central Pacific	Guerrero	Rodrigo Núñez Pérez	Fundación Ecológica de Cuixmala A.C.
Central Pacific	Michoacán	Ricardo Legaria	Gobierno del Estado de Michoacán
Central Pacific	Nayarit	Erik Saracho Aguilar	Hojanay A.C. Hombre Jaguar Nayarit
Southern Pacific	Chiapas	Rodrigo A. Medellin	Instituto de Ecología UNAM
Southern Pacific	Chiapas	Epigmenio Cruz	IHNE Chiapas (Sierra Madre de Chiapas)
Southern Pacific	Oaxaca	Iván Lira Torres	Zoológico de Aragón
Southern Pacific	Oaxaca	Diego Wooldrich/ Iván Lira Torres	Zoológico de Aragón
Yucatan Peninsula	Quintana Roo	Cuauhtémoc Chávez	Instituto de Ecología UNAM
Yucatan Peninsula	Quintana Roo	Gerardo Ceballos	Instituto de Ecología UNAM
Yucatan Peninsula	Quintana Roo	Heliot Zarza	Instituto de Ecología UNAM
Yucatan Peninsula	Quintana Roo	Marco Lazcano	El Edén
Yucatan Peninsula	Yucatán, Campeche	Juan Carlos Faller	Pronatura Península de Yucatán A.C.
Yucatan Peninsula	Quintana Roo	Francisco Remolina	ANP Yum Balam, Conanp
Yucatan Peninsula	Quintana Roo	Carlos Navarro	Onca A.C.

stations can be placed daily, one daily in areas far from the base camp. This depends greatly on the type of vegetation and accessibility of the area. It takes 2 hours on average to place each camera trap.

4. The size of the sampled area is essential. The CAPTURE program works best with populations ≥ 15-20 individuals, which is not very viable in most situations because of the low density of the jaguar and logistic and economic limitations. A minimum sampling area of 64-200 km^2 is required in areas with high densities (Figure 1; Medellín *et al*., 2006). The highest densities recorded are 7-9 individuals/100 km^2 (Chávez, 2006; Chávez *et al*., this volume; Maffei *et al*., this volume). Areas with low densities require a minimum sampling area of 400-750 km^2 (Figure 2). This is because the minimum density recorded for the jaguar is less than one individual/100 km^2 (S. Avila, pers. comm.; Paviolo *et al*., 2005; Rosas-Rosas et al., 2008; C. López-González, pers. comm.).

5. The size of the sampling area can be determined according to logistic limitations, funding or equipment resources, availability of the working team, or jaguar density. It is necessary to determine when to estimate the population or abundance of a species through sampling. The sampling area must be delimited within suitable and unsuitable habitat for the jaguar. Suitable habitat can be defined as an area with plant cover and evidence of habitat use by jaguars, whereas unsuitable habitat is habitat with very little evidence of jaguar presence. The sampling area is divided into sampling cells of equal size that must not exceed the minimum home range of an adult female (10 to 65 km^2), depending on sampling time and vegetation type.

6. The arrangement and number of camera traps should be done as follows: Each sampling cell may contain 3 sampling stations 1 to 4 km apart (Figure 1). In cases where most sampling cells have unsuitable habitat for the jaguar and two sampling stations are relatively close to each other –less than 1 km apart– only one camera station should be used (Figure 2). The number of sampling stations should be limited; even with 20 sampling stations, it would only be possible to sample an area of 250 km^2 at once. The most important study so far on the ecology of the puma was conducted in an area of 2,059 km^2 (Logan and Sweanor 2001). This suggests that the area recommended to monitor the jaguar population in some areas should cover 6,000-8,000 km^2, which is very difficult to implement for logistic reasons. On the other hand, if the cameras are periodically moved or sampling time increases too much, there is a risk of violating the closed population assumption.

The minimum number of stations is 18/100 km^2, that is, 3 stations/16 km^2, the minimum home range for a female in 20 to 60 days (C. Chávez, pers. comm.; Soisalo and Cavalcanti, 2006). At least 4 out of every 9 stations must have two cameras (double stations). Therefore, at least 26 cameras are required for the jaguar survey, with a total number of 18 stations (Figure 1).

Prey species

Sampling with camera traps makes it possible to estimate the abundance of prey species, particularly in areas where animals are difficult to see. Cameras can be placed on trails or paths used by wildlife to generate an index of prey density based on the number of photographs taken per sampling effort. For example, number of photographs of peccaries/100 trap days. However, scope of the relation between the index and actual prey density or abundance remains unknown (Karanth and Kumar, 2002). Due to the habits and sizes of most potential jaguar prey, there will be two types of sampling areas, one for large species with a minimum home range greater than 1 km^2 and one for smaller species. For large species, the considerations of camera trap design are similar to the jaguar's, with a few differences. Sampling will be simul-

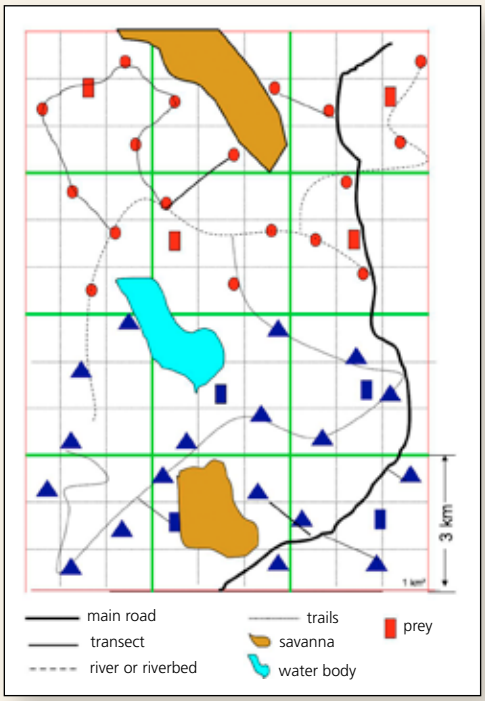

Figure 1. Sample design with camera traps in good-quality habitat or habitat with good plant cover. Sampling cell size is 9 km^2. Circles and triangles show the position of camera trapping stations. The first sampling period is shown in red; the second one is shown in blue.

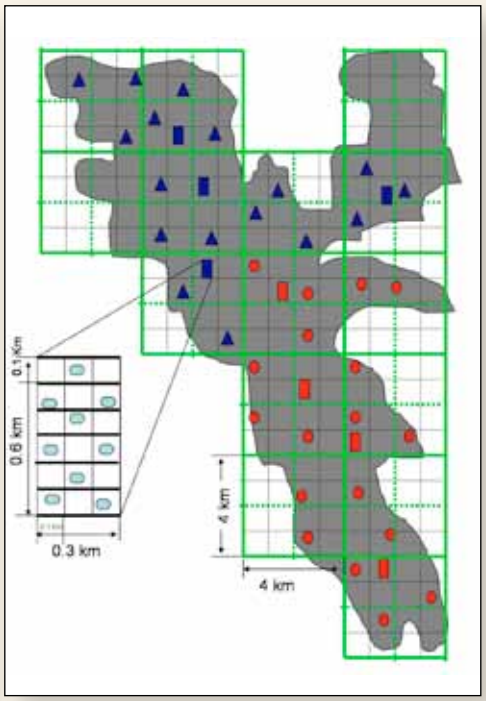

Figure 2. Sampling design in a hypothetical area classified as having good and poor habitat quality. The shaded area shows good quality habitat. Sampling cell size is 16 km^2. Circles and triangles show the position of camera trapping stations. The first sampling period is shown in red; the second one is shown in blue. The area where prey were sampled is highlighted.

taneous to that of the jaguar, but it will last for 10 days –the time it takes a paca to move or change its home range (Beck-King *et al*., 1999).

All the camera trap stations should be placed in one day, and at least one sampling cell should be completed every day, especially in areas far from the base camp. This will depend on the habitat and the accessibility of the area. The size of the sampled area will be 0.2 km^2 for small species such as Central American agoutis (*Dasyprocta punctata*); this is the average minimum home range for this kind of species (Beck-King *et al*., 1999; Chew and Chew, 1970). The sampling area will be divided into sampling cells of a size equal to or smaller than the minimum home range of an adult female or a group of animals, 0.2 km^2 in this case (Figure 2).

Each sampling cell will contain 9 sampling stations 100 to 300 m apart, covering an area of 20,000 m^2 (0.2 km^2; Figure 2). A 1 km^2 grid will be divided into 20 cells measuring 100 x 100 m, 9 of which will be used (600 x 300 m). Each sampling station is considered to cover 100 m^2. Places with the greatest probabilities of photographing prey species should be selected, and places with lesser chances of photographing animals should be avoided. The number of sampling stations should be limited through expert sampling, selecting areas with the most homogeneous vegetation patches. Using more stations and covering a broader area would probably result in recording different groups or populations for some species. Several camera trap studies have calculated frequency of occurrence or density for all prey species, without considering key aspects such as prey species' home ranges, habitat use patterns or size (e.g., Souza *et al*., 2007; Srbek-Araujo and García, 2005). Besides, the sampling has usually been focused on potential prey weighing more than one kilo (Oliveira, 2002).

Two sampling cells should be used for each vegetation type; in the case of the jaguar, at least eight sampling cells are necessary. All the stations must be equipped with one camera, so at least 18 cameras and 8 sampling cells are necessary to assess the relative abundance of prey species.

Final considerations

The shape of the sampling area will depend on habitat quality, topography, and location of tracks, rivers and trails used to access the area. The trapping area should have the smallest perimeter possible. The size of the sampling area will depend on the location, ease of access to place and check the cameras, the number of cameras available and jaguar density in the area. The minimum trapping area suggested is 64 km^2, with cell sizes ranging from 9 km^2 for areas with dense vegetation or a high jaguar density (e.g., tropical areas) to 16 km^2 in open areas (e.g., xeric scrub) or areas with a low jaguar density.

Possible examples of shape and approximate location of traps in a sampling area are described next. Once a sufficiently large and accessible area has been selected, possible camera trap locations can be selected on a map to ensure there are no large gaps. Locations can be georeference and marked on a map to achieve the best possible distribution by selecting some of them. In some cases, it is necessary to open trails to access areas where there are gaps with no cameras. These trails should be opened as early as possible so that the animals become accustomed to using them (Figure 1).

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Species photographed using the sampling design for tropical forests.