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IS TRANSLOCATION OF PROBLEMATIC JAGUARS (PANTHERA ONCA) AN EFFECTIVE STRATEGY TO RESOLVE HUMAN-PREDATOR CONFLICTS?

Systematic Review

ISASI-CATALA, E.

Laboratorio de Manejo y Conservación de Fauna – Universidad Simón Bolívar - Sartenejas – 89000 – Caracas - Venezuela.

Correspondence: zmiliana@gmail.com
Telephone: 0058-212-9063111 ext 6022

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Summary

1. Background

In the case of the jaguar (*Panthera onca*), predation on domestic animals is closely associated with the decrease of available natural prey due to hunting and habitat loss. In spite of the low impact of jaguar predation on livestock populations, the conflict-related hunting of this predator is one of the major threats to its conservation. Several measures have been developed to curb the hunting of jaguars. Among them, the translocation of problem animals has the support of most conservationists, basically because it aims to solve the predation issue without eradicating individuals. This paper, therefore, seeks to assess the outcomes of jaguar relocation programs over the animal's entire range so as to determine whether this management intervention can be effective in improving the conservation status of jaguar populations by tackling conflict-related hunting activities.

2. Objectives

This review investigates whether the translocation of problematic animals is an effective strategy for the jaguar conservation, by improving the status of their populations and/or reduces human-predator conflict

The review also addresses the significance of a jaguar's age and gender to the effectiveness of this type of program; the relation between the types of human activity involved in the conflict and the success of translocation programs as a means to resolve human-predator conflicts; the most frequently used techniques to capture and move problem jaguars; and the criteria to select areas to relocate problem animals.

3. Methods

Searches were performed by an only reviewer between July and December 2008 in the following databases and search engine: IUCN / SSC Cat Specialist Group - Digital Cat Library, Science Direct, Scirus and Scientific Electronic Library Online (SciELO) and Google Scholar. A defined combination of search terms in English, Spanish, Portuguese and French were used. The bibliographic databases of experts, libraries and jaguar specialized sources were examined. Included studies were relevant for the proposed subject (the jaguar) and the intervention (the translocation of problem jaguars), and presented qualitative and quantitative evidence regarding the effectiveness of problem jaguar relocation programs. Studies were selected in three steps: titles and keywords, abstract and entire manuscript. At each step, a second evaluator reviewed all the work to check the selection criteria. The quality of the selected studies was analyzed using defined criteria. The entire manuscript of the selected works was analyzed by a reviewer and the results obtained were summarized and organized in a spreadsheet and in summary tables: narrative synthesis, quality classification and/or evaluation, heterogeneity sources and secondary results, among others. The quantitative result included the survival of

relocated jaguars, number of jaguars hunted and domestic animals preyed upon by jaguars. Additional information was also extracted: persons or institutions responsible for the identification, relocation and monitoring of animals, capture and release location, trapping methods, characteristics of animals translocated and type and duration of follow-up. The expert opinion on the effectiveness of the intervention was recorded for analysis. The quantitative data were analyzed using descriptive statistics.

4. Main results

Out of 3,200 works retrieved from searches, only 10 were selected to be included in the review. From these, the most (7) were classified as opinions of respected experts based on field qualitative evidence. Although the studies showed important results (quantitative and qualitative) on the causes and consequences of jaguar predation on domestic animals and the relocation experience of problem animals, none had sufficient or adequate results to evaluate the effectiveness of the translocation of jaguars for its conservation.

The three translocation programs that were reviewed yielded a low survival of relocated jaguars (28% survival). This, however, cannot be taken as conclusive evidence against the effectiveness of a conservation strategy because the programs evaluated have both design and implementation flaws with respect to the review question. Among the major flaws must be mentioned the fact that only 27,8% of the animals were classified as livestock predators, most of captured animals died (28,6%) or were taken to zoos (22,2%), only six individuals were followed within the area of release and the monitoring time was insufficient to determine the effectiveness of the translocation. The characteristics the area of release and the relocated individuals seem to have played a part in the effectiveness of the jaguar relocation programs that were studied. Other factors that may affect the effectiveness of this conservation strategy are the characteristics of program capture, transfer and monitoring of animals, as well as social and economic situation of human populations related to the program. A secondary analysis of the founded expert's opinions shows that for most of them (60%) the effectiveness of the relocating problem animals as the jaguar conservation strategy was low. However, experts also consider that a continuous, carefully controlled implementation of this strategy could eventually achieve the conservation of this predator.

5. Conclusions

There is very little evidence available to assess the effectiveness of problem animal translocation programs that seek to protect the jaguar, most of which owe their inadequacy to planning and design flaws. As long as the lack of reliable results on the implications of these types of measure persists, it will be impossible to assess the effectiveness of such programs, as well as improve or replace them with better ones. The results may prompt researchers to broaden the scope of their studies and initiate a more rigorous assessment of management and conservation programs for threatened species such as the jaguar.

1. BACKGROUND

The jaguar (*Panthera onca*) is the largest terrestrial predator in the Neotropics and is the only representative of the genus *Panthera* in America (Seymour 1989). It is strongly associated with areas that have considerable vegetation cover, water availability and prey abundance, although it is able to survive in a number of different environmental conditions (Mondolfi and Hoogesteijn 1986; Rabinowitz and Nottinggam 1986; Seymour 1989; Crawshaw and Quigley 1991; Jackson 1992; Rabinowitz 1992; Nowell and Jackson 1996).

Like most other carnivores, the conservation status of jaguar populations is defined principally by habitat conditions and by its interaction with humans (hunting activities, trade, competition for prey) (Swank and Teer 1989; Jackson 1992; Mondolfi and Hoogesteijn 1992; Nowell and Jackson 1996). Up to the 1970s, the species main threat came from poaching activities for its skin. It was for this reason that the jaguar was included in 1973 in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Seymour 1989; Swank and Teer 1989). Today, the jaguar is principally threatened by habitat loss and destruction, indiscriminate hunting of its natural prey and the conflicts that exist between it and humans which are caused by predation of domestic animals (Swank and Teer 1989; Hoogesteijn, *et al.* 1992; Nowell and Jackson 1996). Consequently the species is catalogued as Nearly Threatened (NT) by the International Union for the Conservation of Nature (IUCN) (IUCN 2007).

The sources of threat that affect the species are not independent. Habitat loss and destruction directly affect the jaguar by reducing its shelter availability, and has a negative effect on the populations of its prey which alongside hunting activities notably reduces the jaguar's food availability (Hoogesteijn, *et al.* 1992; Rabinowitz 1992; Hoogesteijn, *et al.* 2002; Sáenz and Carrillo 2002). It is believed that this situation encourages the substitution of the jaguar's natural prey by domestic animals, which leads to financial losses and general animosity towards this predator. This conflict between anthropogenic activities (mainly cattle farming and other domestic animals) and the jaguar has promoted its active persecution and hunting. Therefore in the present day, hunting activities are one of the main causes of mortality (Quigley and Crawshaw 1992; Hoogesteijn, *et al.* 2002; Sáenz and Carrillo 2002; Kelly and Silver 2009).

In order to reduce human-predator conflicts, different strategies have been proposed to manage both predator and domestic animal populations (Swank and Teer 1988; Swank and Teer 1992; Taber, *et al.* 2002). However, the management of domestic animals aimed at reducing predation events have so far not been accepted by farmers as they are costly in terms of effort, time and money (Linnell, *et al.* 1999). These management strategies maintain the coexistence between predators and domestic animals but do not guarantee that no animal will be predated upon.

Some of the methods that have been most widely used to control indiscriminate carnivores hunting activities, have been the selective hunting of problematic animals, and the translocation of problematic animals to areas of reduced human activity (Linnell, *et*

al. 1997; Linnell, *et al.* 1999; Miller, *et al.* 1999; Somers and Gusset 2009). Of these two alternatives, the capture and translocation of problematic animals might be an effective option for jaguar conservation.

The IUCN defines a translocation as “a deliberate and mediated movement of wild individuals or populations from one part of their range to another” (IUCN 1998). This method involves the capturing, transfer and liberation of problematic jaguars in an area within the jaguar’s original distribution where there is low human activity and consequently a lower hunting pressure (Linnell, *et al.* 1997; Jule, *et al.* 2008). The translocation of problematic animals tends to take place in both public and private protected areas. In this way, habitat and prey availability is guaranteed to encourage the maintenance and conservation of jaguar populations.

The translocation of problematic animals is a management strategy that has been widely used for big carnivores like jaguars (Linnell, *et al.* 1997; Linnell, *et al.* 1999; Miller, *et al.* 1999; Jule, *et al.* 2008). However, there are serious limitations such as the difficulty of identifying individuals that predate on domestic animals, costs of capture and transfer of animals, choice of translocation areas, absence of monitoring and continuity of translocation programs, lack of institutional support, (Hoogesteijn, *et al.* 1992; Swank and Teer 1992; Miller, *et al.* 1999). On the other hand, hunting of jaguars may still be taking place in areas where a translocation programs are running due to lack of the programme’s credibility (leading people to eliminate any animal that may be present in the area without reporting the event), and to local cultural values that promote the hunting practice of this predator (Hoogesteijn, *et al.* 2002; Kelly and Silver 2009).

Given that translocation of problematic animals is a potentially effective technique for the conservation of the jaguar, we undertook a systematic review and evaluation of the results of different jaguar translocation programs within its natural range to determine whether they have been effective in improving the conservation status of jaguar populations and in limiting hunting events due to predator-human conflicts.

2. Objectives

2.1 Primary objective

The purpose of this review was to answer the following question: Is the translocation of problematic animals an effective strategy for the jaguar conservation, by improving the status of their populations and/or reduces human-predator conflict?

2.2 Secondary objective

In addition, the following matters were also evaluated:

- Are the age and sex of the relocated jaguars important factors for the effectiveness of this type of program?
- Which techniques for the capture and transfer of the problematic jaguars are the most utilized?

- Which criteria for the selection of relocation areas of the animal problem have been the most utilized?
- Does the success of problem jaguar relocation as a strategy to diminish the human-predator conflict depend on the type of human activity involved in the conflict?

3. Methods

3.1 Question formulation

Most cases of wild carnivores preying upon domestic animals are due to some type of imbalance within the local ecosystem (Hoogesteijn 2003). Even though domestic animals, especially bovines, are potential prey for the jaguar (Hoogesteijn, *et al.* 1992), in most cases predation events by this feline are associated with a reduced number of natural prey available caused by loss of habitat or direct eradication through hunting. Moreover, the isolation of jaguar populations in relatively adequate patches of habitat surrounded by a matrix of areas of human activity raises the possibility of interference between humans and predators.

Despite the low impact of jaguar predation on production activities such as cattle breeding (jaguar predation scores low when compared to other causes of loss of cattle), the persecution and killing of jaguars in Latin America has been one of the major threats to the conservation of this predator (Mondolfi and Hoogesteijn 1992; Quigley and Crawshaw 1992).

There are significant studies suggesting various measures to curb the hunting of jaguars involved in conflicts. Some of these measures are the anti-predator management of cattle, the association between production activities and ecotourism, and the implementation of environmental education. However, while the problem requires an immediate solution, these alternatives would only yield results in the long run, and demand time and money from farm operators. Among the suggested measures, the translocation of problem animals is the one that has the support of the majority of conservationists, because it addresses the issue of jaguars preying on domestic animals without eradicating the predator. The strategy has been applied to other carnivores, but its effectiveness remains in question (Quigley and Crawshaw 1992; Hoogesteijn 2003).

Given the fact that programs for the relocation of problem animals have been suggested as a way to protect jaguar populations, and that several examples of their implementation are available, it is important to confirm if these programs can achieve their intended purpose. It for this reason the present review seeks to determine whether the translocation of problem jaguars is an effective strategy to resolve human-predator conflicts.

The question was structured as follows (Pullin and Stewart 2006):

Subject: The jaguar (*Panthera onca*) throughout its geographical range of distribution.

Intervention: Programs to capture and relocate jaguars that generate conflicts with humans by preying upon domestic animals. The purpose to be achieved by these programs is the conservation of jaguars by preventing or mitigating human-predator conflicts. Problem jaguars should be relocated to areas where they cannot interfere with human activities or where the degree of interference can be tolerable to people.

Outcome measures: Given the question, direct and indirect evidence was sought about the translocation program for problem animals. The proposed direct evidences were: 1) changes in the number of jaguars hunted due to conflicts with human activities in capture and released areas, 2) the survival of relocated jaguars, 3) changes in the number of reported domestic animals preyed by jaguars and, 4) changes in the number of jaguars in conflict area. Indirect evidences were: i) improvement in people's perception and attitude towards the jaguar and ii) change in the people's acceptance and in levels of support for jaguar conservation measures.

Comparators: Works containing temporary comparators of the indicators were searched, considering studies that provide data before and after the translocation program took place. However, studies with spatial comparisons of indicators between areas with relocation of problem animals and areas without these programs were considered.

Design: Included studies were either quantitative (with data that made possible an assessment of the intervention by using specific comparators and predefined variables) or qualitative (with evidence or reports that allow the assessment of the intervention).

Based on this main question, secondary questions were formulated to address the elements that could impact the effectiveness of problem jaguar relocation programs and the success of the latter in achieving the conservation of jaguars: are the age and sex of the relocated jaguars important factors for the effectiveness of this type of program?, which techniques for the capture and transfer of the problematic jaguars are the most utilized?, which criteria for the selection of relocation areas of the animal problem have been the most utilized? and, does the success of problem jaguar relocation as a strategy to diminish the human-predator conflict depend on the type of human activity involved in the conflict?

3.2 Search strategy

Electronic databases and searches on the internet:

The searches were carried out between July and December 2008, in the databases: UCN / SSC Cat Specialist Group - Digital Cat Library, Science Direct, Scirus y Scientific Electronic Library Online (SciELO), and Google Scholar.

The searches for the first four databases and for the search engine Google Scholar were carried out in English, while for the database SciELO the searches were carried out in English, Spanish, Portuguese and French.

The search was performed using the following keywords:

1. *Panthera onca*

2. *Panthera onca* AND Conflict*
3. *Panthera onca* AND “Predation of domestic animals”
4. *Panthera onca* AND "Cattle depredation"
5. *Panthera onca* AND Livestock*
6. *Panthera onca* AND “Human activity”
7. *Panthera onca* AND Relocation*
8. *Panthera onca* AND Transfer*
9. *Panthera onca* AND Translocation*
10. *Panthera onca* AND Management
11. *Panthera onca* AND “Problematic animals”
12. *Panthera onca* AND “hunting”

The scientific name of the species (*Panthera onca*) was utilized in all the searches carried out in the four languages. This search extended utilizing the most representative common names of the species in each language:

English: Panthera onca y Jaguar*.

Spanish: Panthera onca, Jaguar*, Yaguar* y Tigre*.

Portuguese: Panthera onca y Onça*

French: Panthera onca y Tig marqué

For the internet searches the first 100 hits of each search were reviewed. To be included, articles had to be available in Word, Pdf and other document formats.

Other searches:

The personal bibliographic databases of Dr. Guillermo Barreto and of the author were reviewed. Additionally, the libraries of FUDENA and Fundación La Salle were consulted.

A review of the bibliographical list “An extensive bibliography on the jaguar” was carried out (Fitzhugh, *et al.* 1999). In that document an extensive bibliographical list is shown, with 868 works published until 1999.

The works published in four sources specialized in jaguar were reviewed:

- *Felinos de Venezuela* (FUDECI 1992), has summarized 18 works presented during the symposium organized by FUDECI from September 01 to 04, 1991.
- *El Jaguar en el Nuevo Milenio* (Medellin, *et al.* 2002), with 38 works published on biology, ecology and conservation of jaguar.
- *El Jaguar Mexicano en el Siglo XXI: Situación Actual y Manejo. Memorias del Primer Simposio* (Chávez and Ceballos 2006), with 7 works on biology, ecology and conservation of jaguar.
- *Conservación y manejo del jaguar en México: estudio de caso y perspectivas* (Ceballos, *et al.* 2007), with 19 investigation works about jaguar carried out in Mexico.

The search using databases, catalogues and search engines was carried by one reviewer. Bibliographic information was collected from the available works, including the information that was not included in the review after being analyzed pursuant to the

established criteria. This information was organized by using a bibliography manager (EndNote), which included full quotes and the abstract (if available). The records were kept in a database in order to determine the total number of found articles (classified according to keywords and language), the number of selected articles each selection phase and the final number of articles included in the review.

3.3 Study inclusion criteria

All studies that yielded information on the aforementioned subject (jaguar), intervention (the translocation of problem jaguars), indicators and comparators were considered (Pullin and Stewart 2006). This included scientific studies, case reports, reports of management activities, and theses. Priority was given to studies that present quantitative data on the variables mentioned above. However, studies with qualitative data, descriptions or opinions of experts were also analyzed.

Based on the criteria defined above, the most relevant studies for the review were selected in three phases:

1. Title and keywords: only those studies whose title and keywords were associated with the objective of this review were included.
2. Abstract: after applying the first filter, all the abstracts from the selected studies were revised and only the most relevant ones were chosen.
3. Entire manuscript: all relevant papers were read in full to determine which were suitable for analysis.

In each selection phase, an assistant assessed the entire sample of studies to verify whether the previously mentioned criteria were clearly defined and whether they had been correctly used to include or exclude studies from the review (Pullin and Stewart 2006). The results were compared using a Kappa analysis, in which criteria were considered adequate and replicable if the result of the analysis was equal to or greater than 0.6.

3.4 Study quality assessment

The quality of the studies was determined from the analysis of the entire text of the selected documents by a single reviewer. The analysis was performed using the following criteria:

Study design:

Collecting of samples: random correct (1), non-random correct (1), random incorrect (0.5), non-random incorrect (0).

Sample size: adequate (1), insufficient (0.5), n = 1 (0), unspecified (0)

Use of comparators: with comparator and controlled conditions (1), with comparator and uncontrolled conditions (0.75), with controlled conditions but no comparator (0.25), with uncontrolled conditions and no comparator (0)

Selection of statistical data: adequate (1), inadequate (0.5), lacking (0)

Experimenter bias:

Population selection: random (1), spatial autocorrelation (0.5), temporal autocorrelation (0.5), spatial and temporal autocorrelation (0).

Measures to mitigate selection bias: Yes (0.5), No (0).

Procedure: random replication (1), pseudo-replication (0.5), no replication (0)

Measures to mitigate procedural bias: Yes (0.5), No (0)

Detection of the object of study: those with the same probability of being detected (1), those with a different probability of being detected (0)

Measures to mitigate detection bias: Yes (1), No (0)

Omission: closed population (1), open population (0)

Measures to mitigate omission bias: Yes (1), No (0)

Scale of process: adequate (1), inadequate (0)

Scale of experiment: adequate (1), inadequate (0)

Scale of analysis: adequate (1), inadequate (0)

The highest score in this analysis is 11 and the lowest 0. All the studies with a score equal to or higher than five were selected for the quantitative analysis.

Further, studies deemed adequate for the quantitative analysis were classified in categories I and II (Table 1), according to the hierarchical criteria adapted from the models proposed by Pullin and Knight (2001 and 2003). Studies that scored less than five or were not analyzed according to the mentioned criteria (particularly when dealing with narrative syntheses) were classified in categories III and IV depending on their content, and were included for qualitative analyses.

Table 1: Criteria for the classification of study quality
(Pullin and Knight 2001; Pullin and Knight 2003)

| <i>Category</i> | <i>Criteria</i> |
|-----------------|--|
| I | Strong evidence from well designed experiments (controlled and random experiments) with an appropriate sample size. |
| II-1 | Evidence from well designed controlled experiment but without randomness. |
| II-2 | Evidence derived from a comparison of differences between different locations or situations that are or aren't influenced by the independent variable ("treatment" vs. "control"). |
| II-3 | Evidence derived from several time series or blunt results of uncontrolled experiment. |
| III | Opinions of experts which are based on qualitative field results, descriptive studies and reports from expert committees. |
| IV | Inadequate evidence due to methodological problems (simple size, duration, etc.) or unexplained evidence. |

3.5 Data extraction and synthesis.

One reviewer extracted, summarized and organized the data in ad hoc electronic forms. The qualitative data extracted were expert opinions on the effectiveness of the translocation, observations on identification, capture and transfer of animals, level of

human-predator conflict and expert opinion on the potential of relocation as a conservation strategy.

Qualitative data relating to secondary questions were entered into electronic sheets as evidence of the impact that some of the factors may have on the outcomes of the intervention. These qualitative data were persons or institutions responsible for the identification, capture and transfer of animals, capture location, trapping methods, age, sex and predator behavior of animals translocated, release place, type and duration of follow-up and person or institution responsible for monitoring. Some quantitative data related to indicators specified above were extracted: the survival of relocated jaguars, number of jaguars hunted due to conflicts with human activities, domestic animals preyed upon by jaguars.

The effectiveness of jaguar translocation programs can vary for several reasons, which are mainly related to the biological characteristics of the species, the area selected for the release of the problem animal, and the social characteristics of the human populations involved in the conflict with the predator. It is for this reason the present review tried to determine the effect of the animal's age and sex on the effectiveness of a translocation program, the criteria for selecting release areas, and the relation between the human activities involved in the conflict with the success of relocating problem jaguars as a means to reduce human-predator conflicts.

During the extraction of data, the following study characteristics were recorded: location, date, duration, researcher level, study objectives, methods, major conclusions, study quality category, score for study design and experimental bias, the aptitude of studies to be included in the review as a narrative synthesis, synthesis, semi-formal, secondary synthesis, or meta-analysis, and the sources of heterogeneity and bias. The heterogeneity and bias factors considered in this review are the following:

- Ecological factors and species characteristics: region or locality, surface, habitat, presence of other predators, local threats for the jaguar, age, sex, health and predator behavior of translocated individuals.
- Method of identification, capture, relocation and release of problematic animals: techniques for the follow-up and identification of problem animals, degree of conflict between human and jaguar, Capture, relocation and release methods, selection of release areas, protection, management and follow-up of relocated jaguar, duration and continuity of relocation program, and researcher's level of expertise
- Social and institutional factors: cultural value of the jaguar, stakeholders, land use, environmental education and support for the program, support from experts and researchers, institutional support and funding, and ethical values

3.6 Data synthesis

Summary tables were created to record the most significant aspects of each of the analyzed studies as well as a narrative synthesis describing each of the studies. The quantitative data featured in the various papers were compiled and summarized in a table, and then analyzed using descriptive statistics and presented within the text or in graphs.

4. Results

4.1 Statistics and description of studies in the review

The search made in electronic databases, search engine specialist databases, libraries, and conference proceedings showed a total of 3,200 works (not duplicates), which were included in EndNote pursuant to the established search criteria.

Of the 3,200 works, only 109 met the inclusion criteria according to their title and keywords (Filter 1), which accounts for a search effectiveness of 3.4%. This selection was confirmed by a collaborator, and a similar selection was obtained (106 studies), which shows that the criteria used was well defined and analyzed ($Kappa = 0.980$, $p < 0$, $n = 3.200$). The four works excluded during the confirmed selection were those with a general title (“The Jaguar” or “Jaguar”) or keywords, so their selection was too complex. In those cases, a quick review of the entire manuscript (if it existed) was made in order to clarify the selection.

The 109 works were evaluated according to their abstracts (Filter 2), and 26 met the inclusion criteria ($n1 = 26$, $n2 = 22$, $Kappa = 0.845$, $p < 0$, $n = 109$). Finally, of the 26 studies 20 had a complete text available for review (Filter 3). Of the 20 studies whose full text were evaluated, 10 were selected ($n1 = 26$, $n2 = 26$, $Kappa = 1$, $p = 0.05$, $n = 16$) (Appendix 1, 6 and 7).

Most of the papers that were selected (7) were opinion articles (appendix 1 and 3), in which the authors analyzed the situation of jaguars, and discussed several conservation strategies. Many of the papers presented original qualitative and quantitative (7) data that were useful to the review, whereas the rest only featured expert opinions. Only three of the studies were experimental.

Some of the studies’ authors and the information they present are repeated (4). Even though the qualitative synthesis of each of these works was included, the information provided by different works of the same author or authors is very similar; therefore, the analysis of the qualitative and quantitative data obtained was made taking these repetitions into account.

The studies that were discarded did not provide any useful information for the review. Most of these papers simply proposed management programs that included the relocation of problem jaguars (Appendix 7).

4.2 Study quality assessment:

The ten included studies were put into three categories in accordance with the proposed criteria (Table 1, Appendix 2). Half of the papers belong to category III (expert opinions based on field observations). Three of the studies were classified into category IV (evidence rendered inadequate by methodology issues or unexplainable conflicts of

evidence), since they do not explain how the described data were collected. Only two papers were classified as type II-3 (solid results from uncontrolled experiments).

The quality of the three experimental studies was assessed as a way to verify the validity of the data and the opinions obtained from them (Appendix 3). Only one of the studies (Rabinowitz 1986) scored higher than 5 (6.25). The other two (Rabinowitz and Nottingham 1986; Sáenz and Carrillo 2002) scored 4.5 and 5, respectively. In spite of the score, the papers included in the review cannot be subjected to a complex quantitative analysis, because most of the obtained data were the byproduct of the proposed experimental design. In these cases, assessing the quality of the study is much more difficult than one would expect.

4.3 Narrative synthesis

The studies included in the review were summarized in a table (Appendix 3), in which the following information was provided: 1) reference, 2) country, locality and duration of the project, 3) project objective, 4) a brief description of the experimental design and the methods employed, and 5) a brief description of the major outcomes and most relevant conclusions of the study.

The studies yielded significant results regarding the causes of jaguar predation on livestock, the consequences of predation events on production activities, the proposed measures to tackle this problem, and observations on the effectiveness of the translocation of problem animals as a conservation strategy and a means to resolve human-predator conflicts. Some of the papers provide quantitative data on the effectiveness of these programs and the serious nature of the conflict (Appendix 4).

The reasons for heterogeneity between each of the studies are not very distinct (Appendix 5). As for the sources of heterogeneity associated with the landscape or the species, the studies that were analyzed only provided observations from four countries: Venezuela, Brazil, Belize and Costa Rica, all of which are quite different in terms of their environmental policies, landscape, population density, economy, etc. In every one of the cases, jaguars were not the only conflictive predators, as pumas (*Puma concolor*) were also present. Moreover, poaching and loss of habitat are the main sources of threat. Even though not every author assessed the differences in relocation effectiveness given the characteristics of the individuals to be relocated (sex, age, etc.), all of them agree on the fact that the programs should only be implemented with predators or conflictive animals.

Assessing the heterogeneity introduced in the analysis by the design of the relocation program turned out to be very difficult, since many of the authors did not include information on the matter. Only one of the papers provides an explanation about the significance of identifying a problematic jaguar and the strategy to do so. The methods of capture usually involve traps with various types of bait or expert hunters using tranquilizer darts. None of the studies mention how to move the animals or select the area of release. The follow-up usually relies on telemetry, but this was employed in very few of the reported cases. The duration of the relocation programs and the follow-ups, as well

as the training received by the people involved in such programs are important sources of heterogeneity. However, very little information was provided on these issues.

As for the social factors, almost every study is based on events that have taken place in areas where cattle breeding is the main economic activity and the stakeholders involved in the conflict are usually stock breeders, farmers, local villagers and managers of protected areas.

4.4 Review outcomes:

4.4.1 Synthesis of quantitative data

There were evidence from the implementation of three jaguar relocation programs (Appendix 6) (Rabinowitz 1986; Hoogesteijn, *et al.* 2002): two in Venezuela (one carried out by a government agency and the other one implemented by the authors of the study), and one in Belize (a government program with an expert consultant). These programs have yielded the relocation of 18 jaguars between Venezuela (16 individuals) and Belize (2 individuals). In 66.7% of the cases, the data do not specify whether the relocated jaguars had preyed on domestic animals. However, in 27.8% of the cases the animals had done so. Only in the case of one relocated predator did the researchers acknowledge not knowing about the interactions between the jaguar and domestic animals.

Among the methods most used to capture jaguars are traps baited with goat or dog meat (27.8% of cases), tracking dogs to follow the predator, and tranquilizer darts to capture it (50% of cases).

Although the age of the animals is not mentioned in 61.1% of the cases, 11.1% of the relocated jaguars were old adults (Fig. 1) and 11.1% were subadults or cubs. Only 16.7% of the relocated jaguars were adult. As for the sex of the animals, most were females (56%), whereas males represented in 39% of the cases (Fig. 1).

Of the total number of reported animals, two died while being captured and four were taken to zoos. The rest were released in protected areas or private properties. In many cases, however, the area of release was not specified (Fig. 2).

Of the 12 relocated animals, only half were fitted with radio transmitters for follow-up purposes. The follow ups took place during very brief periods (from 3 weeks to 8 months).

Of the predators that were relocated, two were killed by poachers. Evidence was found indicating that one of these two animals had preyed on livestock after being released. One of the other individuals had left the area of release after five weeks, so it was impossible to confirm its survival. Aside from the animals that were taken to zoos, the survival rate recorded in these translocation programs was very low (Fig. 3). Only four of the 14 animals released in the wild survived the process of translocation, at least during the monitoring period. An equal number of animals died during the translocation. However, for six of the animals released survival is unknown by the lack of monitoring.

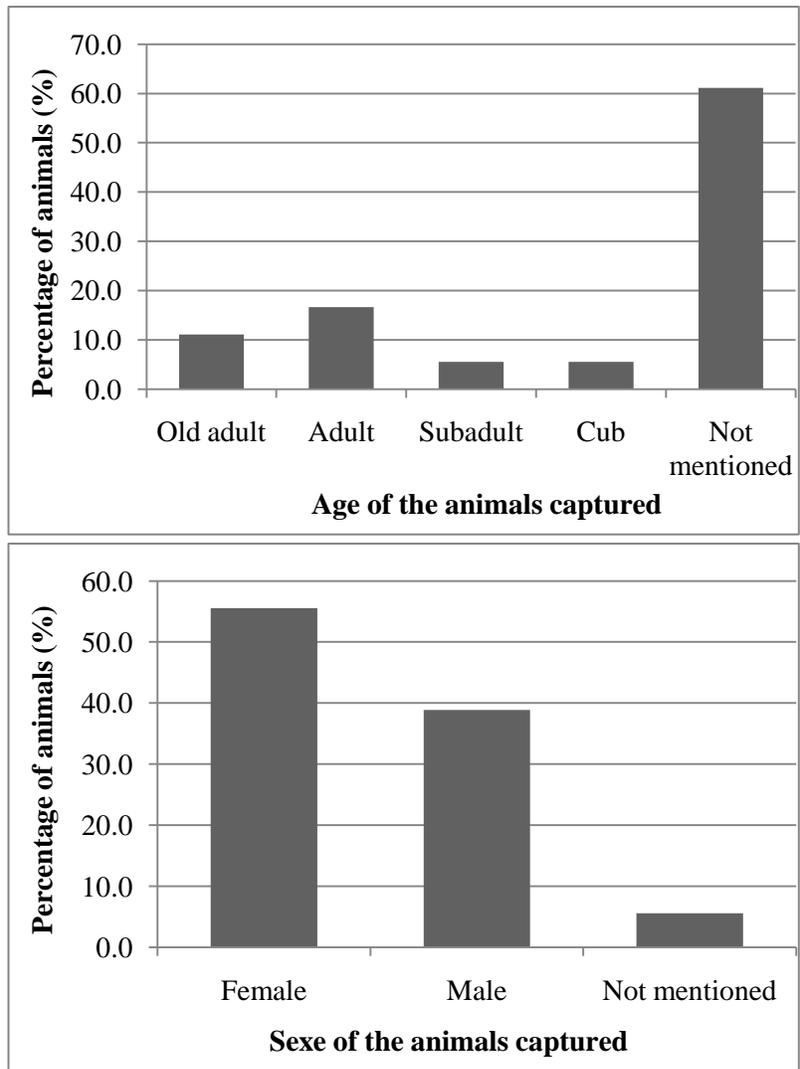


Figure 1: Relocated jaguar distribution by age and sex ($n = 18$).

The animals registering the highest rate of survival were those released in large protected areas (Aguaro-Guariquito National Park) or regions located far from human activities (Caura River Forest Reserve). On the Caura River Forest Reserve (Bolívar, Venezuela), a female jaguar and its cub were followed for eight months after being translocated. Although the female was considered problematic, the jaguar established territory in the area of release, surviving at least during the monitoring period. During follow-up the cubs left the mother and settled in the area. Another female released in the Aguaro-Guariquito National Park (Guárico, Venezuela), was followed for five months, during which it remained inside the park area. Local ranchers claim that this animal continued preying on livestock in the area of release, but this has not been confirmed. Jaguars were most likely to be hunted when human activities took place near the area of release. (“Hato El Frio” cattle ranch and Cockscomb Basin).

In the relocation cases of Aguaro-Guariquito National Park, local villagers expressed concern about having the animal in the surroundings. However, presence of the species had been reported before in the area of release.

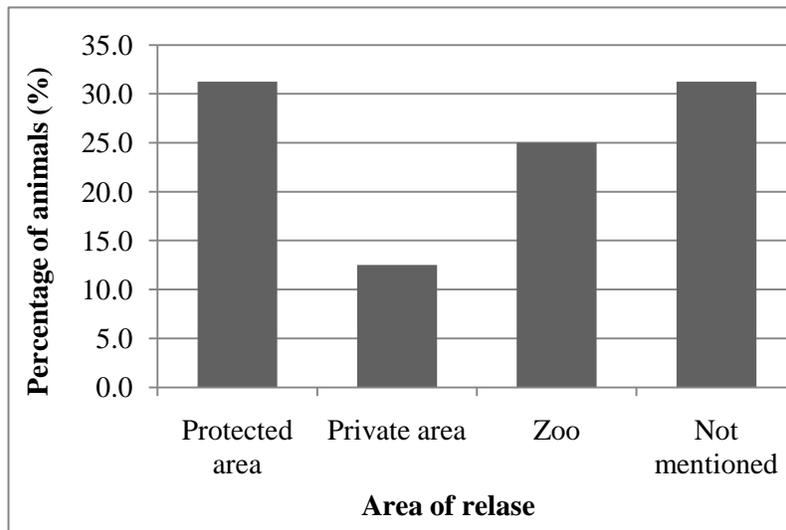


Figure 2: Areas where jaguars were released during the implementation of the assessed programs ($n = 16$)

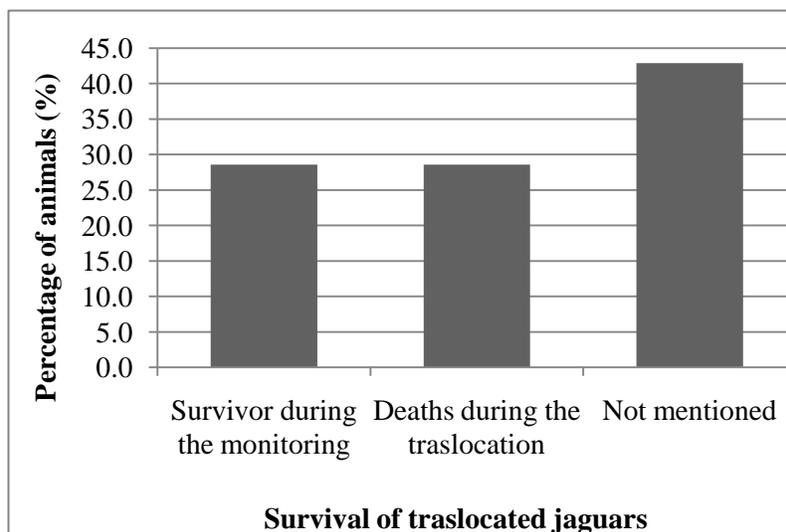


Figure 3: Jaguar survival during the assessed relocation programs ($n = 14$)

In the case of the female jaguar that was released and hunted in the Cockscomb Basin, Belize, Rabinowitz (1986) points out that the predator was set free in a location where other jaguars were not present (the idea was to minimize conflicts over territory). The female remained in the area for three weeks, a period in which it displayed a behavior pattern similar to local jaguars that were not considered problematic (predominantly nocturnal). Eventually, the animal moved closer to open pastures, where besides preying

on livestock (two dead calves were reported) it started to modify its behavior, becoming more active during the daytime.

4.4.2 Synthesis of observational reports

According to most experts (60%), the effectiveness of relocating problematic jaguars is low, although 40% think that removing the predator from the area of conflict is a potential solution (Fig. 4). Experts attribute the low effectiveness of these programs mainly to failures in identifying the problem jaguars and lack of control and continuity of programs. The general opinion of the experts suggests that ensure the correct identification of individuals and maintain strict control of medium and long term is key to ensuring the effectiveness of this conservation strategy.

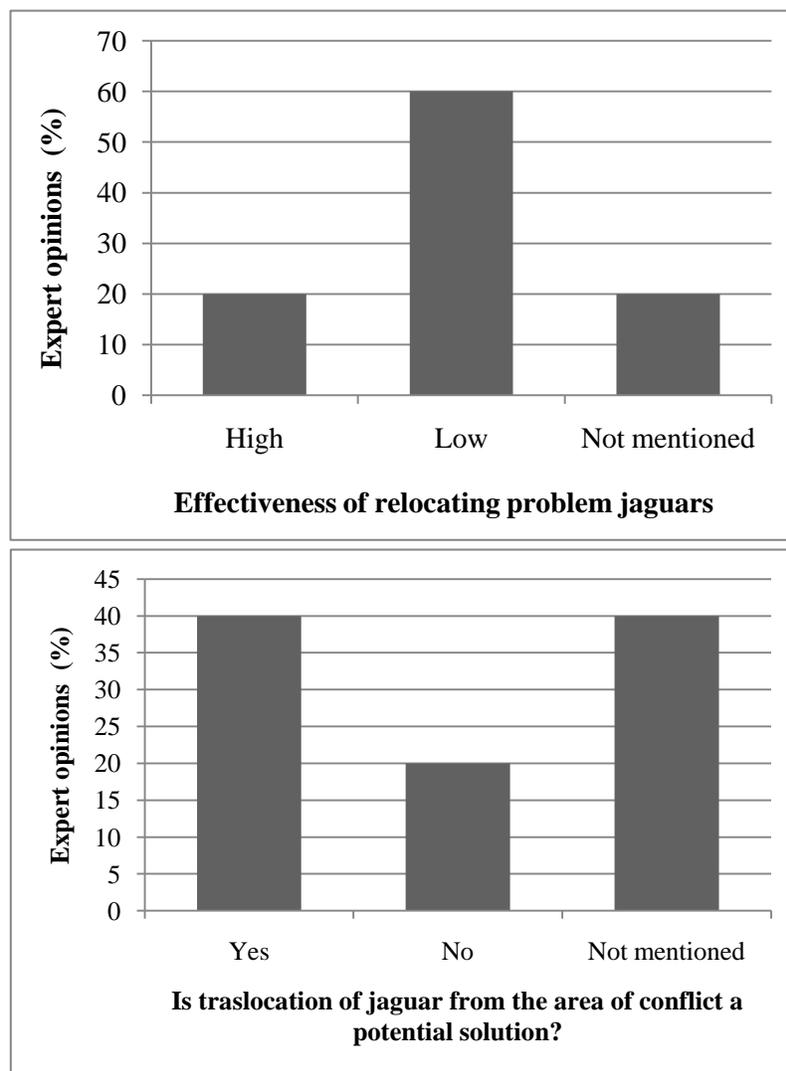


Figure 4: Expert opinions on the effectiveness achieved up to date and the potential effectiveness of relocating problem jaguars ($n = 5$).

5. Discussion

5.1 Evidence for effectiveness:

During the review, no quantitative evidence was found of the effectiveness of relocating problematic animals as a means to curb the hunting of jaguars and promote its conservation. The reviewed studies, however, did not focus on this type of conservation strategy, but did provide some indirect evidence of its effectiveness, as well as expert opinions based on field experience or data.

Most experts believe that this conservation practice is not very effective when it comes to protecting the jaguar. Many highlight the fact that these jaguar translocation programs lacked a sound follow-up process and that the area of impact was too limited, as the benefits were uncertain and felt only on a very local scale (Hoogesteijn, *et al.* 1992; Hoogesteijn, *et al.* 2002; Hoogesteijn 2003). Even without quantitative data to support it, the expert opinion reflects a common outcome for the experiences of translocation of carnivores in the world. Different experiences of translocations and reintroductions of endangered carnivore species for conservation purposes have average success rates ranging from 11% to 53%, which suggests that the use of these interventions as a conservation tool needs to be further investigated and improved upon in order to ensure that they are viable options (Linnell, *et al.* 1997; Jule, *et al.* 2008).

The main critique of this type of program, according to experts, is that the survival rate of relocated jaguars remains unknown and that the impact of removing the predator from the area of conflict has not been assessed (Hoogesteijn, *et al.* 2002; Hoogesteijn 2003). Most of the experiences of a translocation of carnivores in the world reflect this reality: little monitoring of animals and lack of evaluation of the effectiveness of programs, both commonly attributed to time and budget constraints (Linnell, *et al.* 1997; Miller, *et al.* 1999; Jule, *et al.* 2008; Kelly and Silver 2009).

The experts also believe that removing a problem jaguar may help prevent predation on cattle and poaching (Medina Padilla, *et al.* 1992; Quigley and Crawshaw 1992; Hoogesteijn, *et al.* 2002). However, carnivore translocations are usually risky and expensive, and a number of biological and non-biological factors can influence success (Linnell, *et al.* 1997; Linnell, *et al.* 1999; Miller, *et al.* 1999). Biological factors include knowledge of genetics, demographics, behavior, disease, and habitat requirements. Moreover, non biological factors that may affect the effectiveness of translocations include legal framework, fiscal and intellectual resources, monitoring capacity, goals of the translocation, logistic challenges, and organizational structure of decision making. These factors are the key to determining whether or not to try to translocate jaguars problem if this translocation will be successful and which strategies to ensure effectiveness and efficiency in the short and long term (Linnell, *et al.* 1997; Miller, *et al.* 1999; Kelly and Silver 2009; Somers and Gusset 2009)

In this sense, the effectiveness of translocation of problem jaguar depend not only on the animal and the area of release but also on the continuity and consistency of the relocation program (Mondolfi and Hoogesteijn 1986; Mondolfi and Hoogesteijn 1992). Being able to accurately identify a jaguar that is preying on livestock and design an adequate program for the capture, relocation, release and follow-up of a problem predator is

critical. A program assessing livestock predation events by jaguars or other large predators should also be put in place so as to get an idea of its effectiveness, not only in terms of jaguar conservation, but also in terms of benefits to humans (Hoogesteijn 2003; Kelly and Silver 2009).

Some of the studies that were analyzed point out to a lack of evidence regarding the effectiveness of such a measure, thus highlighting the need to keep testing (Quigley and Crawshaw 1992; Sáenz and Carrillo 2002). However, one must also add the need to increase the study of experiences of other large carnivores translocation, as well as the need to improve the design the program and the assessment process (Linnell, *et al.* 1997; Kelly and Silver 2009). The three relocation cases that were analyzed in the present review seem to have both design and implementation flaws with respect to the review question. The fact that only 27.8% of the animals were classified as livestock predators, that the majority of the animals that were captured died or were taken to zoos, that only six individuals were followed within the area of release and that the follow-up did not last enough to determine how the animal was settling and behaving, could lead us to think that these programs were not sufficiently planned. Moreover, nothing is mentioned about collecting data from the jaguar or the livestock predation incidents that would help in assessing the potential effect of this management practice. According to Kelly and Silver (2009), most of the experiences of translocation of problem jaguars have been made opportunistically. Most of these experiences are still major gaps in the definition of objectives and strategies of the translocations, which is reflected in its low efficiency, poor monitoring and lack of disclosure of their results.

The only indicator of the program's effectiveness that was mentioned was assessing the survival of relocated animals. This assessment, however, was inadequately carried out. Other potentially significant indicators are: the levels of livestock predation, both in the area of conflict and the area of release, which would indicate whether the problem has been solved or simply transferred to another area; the number of jaguars being hunted (many studies have confirmed the fact that by pulling the problem predator out of the area of conflict the number livestock predation incidents decreases); and a larger or more stable jaguar population, both in the areas of capture and release. On the other hand, an increased level of tolerance and a shift in the attitudes of people toward the presence of the predator could be taken as an indirect indicator of the effectiveness of this type of program, and the reduction of human-predator conflicts.

Even though the data collected from the three jaguar relocation programs are not of sufficient quality to assess the effectiveness of the conservation measure, the researchers found that the percentage of animals that survived (28.6% up to the end of the follow-up) is equal to the percentage of animals that died (28.6%). The effectiveness of the measure does not seem too high given this indicator. Three of the dead felines were considered as potentially conflictive or had already been attacking livestock. According to this, the jaguars that are relocated for preying on domestic animals are likely to repeat this behavior if they are released in areas close to where cattle breeding takes place. Moreover, relocating a problematic jaguar to an area where it can proceed with its conflictive behavior would make cattle breeders even less cooperative in achieving the

conservation of the animal (Hoogesteijn, *et al.* 1992; Medina Padilla, *et al.* 1992). The aforementioned result indicates that conservation practices such as the relocation of problematic animals should be complemented with environmental education in order to improve people's tolerance toward the feline, as well as more direct actions such as creating protected areas where jaguars can be released and sheltered without the possibility of preying on domestic animals (Linnell, *et al.* 1999; Jule, *et al.* 2008).

Although it is not possible to assess the impact of relocating problem animals as a way to address the conservation of jaguars, it is possible to answer the question "Is there enough evidence of the impact of these programs on jaguar conservation?" Based on the results obtained in this review, it is worth noticing the lack of evidence in the available or published literature to carry out the assessment. The few cases that can be analyzed are inadequate. There may be studies that yield important results on this matter but they are not easily accessible.

5.2 Reasons for effectiveness variation:

According to secondary results extracted from the studies that were analyzed (Appendices 4 and 6), there are a series of factors that may impact the effectiveness of a jaguar translocation program, as they can determine the ability of a predator to settle in a new environment, and eliminate or mitigate human-predator conflicts. These factors, most of which were defined before carrying out the present review, are associated with the characteristics of the species and the release area, the design of the program to capture, move and release the problematic animal, people's perception of the predator, and the various stakeholders involved in the conflict (Linnell, *et al.* 1997; Miller, *et al.* 1999; Kelly and Silver 2009).

Among the main factors are:

- The characteristics of the individual to be relocated: the age, sex, health, and behavior of a captured jaguar may affect the likelihood of survival in a new area (Linnell, *et al.* 1999; Miller, *et al.* 1999; Somers and Gusset 2009). Although the impact of these factors on the effectiveness of the programs is not very clear in the three cases that were appraised, many of the researchers report that most problematic jaguars are old individuals with a disease or malformation that makes it ever more difficult to feed on their natural preys (Rabinowitz 1986; Hoogesteijn, *et al.* 2002; Hoogesteijn 2003). Therefore relocating the animal would not necessarily guarantee a solution to the conflict, as it would one only transfer the problem to another area. In this sense, Miller *et al.* (1999) considers that "translocating problem animals as a cure for livestock depredation will probably have more cosmetic value than conservation substance, and it may only deflect attention from the deeper questions about existing ecological conditions that encourage predation on livestock".

The same happens with those animals that prey on livestock on a regular basis. These "fattened" individuals present changes in their diet and behavior that would compromise the effectiveness of a relocation program, which was the case, according to Rabinowitz (1986), of the female that was relocated and hunted due to inference.

In the three programs that were analyzed, most relocated jaguars were females

(56%). However, the majority of reported livestock predation incidents are associated with males or females with cubs (Linnell, *et al.* 1999; Miller, *et al.* 1999; Sáenz and Carrillo 2002). Apparently, the relocation programs for problem animals did not target the right individuals. Supporting this is the fact that, of the 18 animals that were captured in the three programs, only 27.8% were reported as cattle predators, and none of the programs provided information on the methods used to identify the individuals that needed to be relocated. In light of this, one may wonder if the captured jaguars were the problematic ones and if the results reflect a larger number of females given their likelihood of being captured as a consequence of their range and mobility. This may explain the poor effectiveness of the evaluated programs.

- The selection of the release area: as it was mentioned before, the area of release is key to the success of a relocation program for problem animals such as the jaguar (Miller, *et al.* 1999; Kelly and Silver 2009). Before considering an area for release, one must first verify whether it is protected and isolated, whether it is the only refuge available in the region for that particular species, and if there are centers of human activity nearby that could pose a threat to the survival of the animal. According to Miller *et al.* (1999) it is absolutely necessary determining the amount and type of habitat required and the cause of decline for the species to be translocated. If sufficient habitat is not available or the cause of decline has not been eliminated, it is nearly impossible to justify a translocation
- Most of the relocated jaguars that were hunted during the implementation of the evaluated translocation programs were located near areas where human activities took place and were thus considered as a potential threat or even as livestock predators. This is the case of females released in the Hato El Frio (Apure, Venezuela), which was hunted by poachers to persist in preying on livestock in the area of release (Hoogesteijn, *et al.* 2002). According to Rabinowitz (1986) the variation in the pattern of activity and the persisting predation on domestic animals found in the female that was relocated and hunted in the Cockscomb Basin, in Belize, could be taken as indirect evidence of the low effectiveness these types of program have when the areas of release are near centers of human activity. Moreover, the release area must be suitable for the establishment of new individuals. The availability of prey, cover and water is essential for establishing translocated individuals, and it is limited by the carrying capacity of the area and the presence of other jaguars. The study of habitat availability and the presence of other jaguars in the area of release are critical to ensuring the success of the relocation. In the case of the two animals moved to the Cockscomb Basin, Belize, the release was made taking into account the territories of the resident jaguars. However, none of the released animals was established in the area. The female established a territory near farming areas, where he began preying on livestock, which was hunted five weeks later. After a short stay in the area, the subadult male moved away without being able to be reached again (Rabinowitz and Nottingam 1986; Rabinowitz 1992).

Other factors could not be analyzed in the present review, such as the design, execution and assessment of the relocation programs, and the characteristics of the human

populations involved in the conflict. As for the relocation programs, the lack of rigor in the identification of problem animals, the lack of distinct criteria to select the area of release, and the lack of follow-up regarding both the animals and the program itself could be some of the causes of the low effectiveness reported by researchers. Other factors, such as a follow-up of the conflict, the appraisal of capture techniques and the implementation of additional conservation measures like environmental education can be critical in guaranteeing the effectiveness of a relocation program.

One of the most important factors for the implementation of a program of translocation of problem animals is the definition of goals and objectives clear and achievable. In this sense, it is necessary to consider questions such as: what legal framework exists, does the program comply with laws? is there an active research program to devise tactics? Are there sufficient fiscal and intellectual resources to maintain the program? Will the program be adequately monitored? what are the goals of the traslocation? What logistic challenges must be overcome? Is there an appropriate organizational structure for making decisions? (Linnell, *et al.* 1997; Miller, *et al.* 1999; Kelly and Silver 2009) If we do not have the right answers to these questions, the success of any translocation program be diminished, having made a vain effort for the conservation of large carnivores

When human populations are involved in the original predation conflict or in a new one in the area of release, several socioeconomic factors can impact the effectiveness and tolerance for the jaguar relocation program (Linnell, *et al.* 1999). Among these factors are the following: the education level of the population, the economic activities developed within the community and its economic status, land use, population density and distribution, and the relation between the community and other management/conservation practices (Conforti and Azevedo 2003; Altrichter, *et al.* 2006).

5.3 Limitations of the review:

The main limitation faced in the present review was the lack of availability of quantitative studies. The relatively large number of narrative papers does not allow for a reliable assessment of the qualitative or quantitative data found in such studies. Although in some cases experts complement their opinions with data, most observations are not based on objective data, but on speculation grounded on previous experience. Additionally, the data included in this review was collected from three relocation programs that cannot be accurately assessed due to a lack of information regarding their design and implementation. These results, therefore, could turn out to be inadequate.

Further efforts would be required when searching for grey literature in order to gather higher quality data to assess the effectiveness of translocation programs for problematic animals as a means to foster the conservation of jaguars.

Other limitations related to the review process are:

Search for information:

First on the list is the low efficiency of the searches carried out through electronic databases and search engines. Although the proposed keywords produced a large number of hits, most of these were irrelevant to the jaguar and the intervention study. Thus, a new

type of search would be required if this type of review is to be repeated for the jaguar or any other subject.

Even though the electronic search yielded a significant number of hits when the various names of the subject were used separately (“*Panthera onca*”, “yaguar”, “jaguar”, etc.), most results had no relation with the review or, in many cases, with the jaguar, so they had to be discarded from the analysis. When the names of the subject were used in combination with the remaining keywords, the searches yielded very few hits (in some cases these were duplicate search results) or no hits at all.

Data availability:

Despite the significant threats jaguars currently have to face in their entire range of distribution, it is worth noticing that most of the literature that was compiled focuses on the collecting of basic data regarding the biology and ecology of this predator. The lack of basic information may seem to curb the implementation of jaguar conservation programs, but there is, however, a significant number of baseline studies about this large feline. Filed in the database were 1,354 papers, including peer reviewed articles, articles for the general public, and grey literature (theses, reports, action plans, etc.). An analysis of this database revealed a significant amount of papers on the general biology, diet, population, habitat use, and sources of threat to the species. Most of these papers point out the significance of implementing conservation programs, and list priority measures for the conservation of jaguar populations. Environmental education is among those measures, along with the creation of protected areas and the management of human-predator conflicts. In terms of animal relocation programs, however, none of the papers that were studied analyzed the planning, implementation, and much less evaluate the efficiency of programs geared towards the conservation of the jaguar. One of the main limitations encountered in this review was the lack of access to specific literature to address the formulated question.

A significant amount of material on relocation programs for problematic jaguars probably exists in other countries, such as Mexico, Belize, Costa Rica, and Brazil, but it has not been made available. The lack of grey literature was another limitation faced in the review.

Also worth mentioning is the fact that in some cases it was impossible to find a paper’s entire script to carry out an analysis. Those papers had to be discarded from the review without knowing if they contained key data that would help assess the effectiveness of the studied intervention in the conservation of jaguars (Appendix 8).

Limitations of method:

Selecting a group of studies for the review based on the proposed filters turned out to be more complex than expected, mainly due to the quality of the information contained in each of the sections that needed to be assessed. The papers that were being analyzed using filters 1 and 2, and that presented vague information about their content, were read in full (Filter 3) to confirm whether they could clear the next selection phase. Although the measure was useful to reduce the possibility of rejecting a paper that could yield

important data for the review, it also rendered the selection process more complicated and slower than expected.

The process by which the studies included in the review were assessed turned out to be more complex than expected. Even though the sources of bias and experimental design issues were clearly defined and a value scale was established to assess their consideration, some of the studies did not feature details in their experimental design, thus complicating the identification and assessment of potential sources of error.

Most of the points to be assessed seem to require a new answer category representing those cases in which the score should be zero (Non-specific = 0). However, with this measure many studies will end up being classified as “inadequate” for the quantitative analysis of the review, regardless of their high degree of design and control.

6. Conclusions

There is not enough available evidence to assess the effectiveness of animal relocation programs aimed at protecting jaguars. Most programs are considered inadequate due to flaws in planning and design.

Most experts agree on the fact that jaguar relocations have not been very effective, but they also believe that carried out under strict conditions and on a permanent basis it would turn into a potential tool for the conservation of the predator.

The three reviewed relocation programs show a low survival rate of relocated jaguars. However, this cannot be taken as conclusive evidence of the effectiveness recorded by this conservation strategy given the design and evaluation flaws present in those programs.

The characteristics of the individuals and the area of release are factors that seem to have had an impact on the jaguar relocation programs that were studied. Other factors that require consideration are the characteristics of the programs for the capture, relocation and follow-up of animals and the socioeconomic conditions of the human populations involved in the conflict and the relocation program.

6.1 Implications for conservation:

Given the current status of the jaguar, it has become necessary to reflect upon the efforts made to resolve the human-predator conflict. Since the relocation of problem animals is one of the major proposals for the conservation of jaguars, the lack of implementation and poor evidence base is worth reporting. The existence of few concrete cases and the lack of rigor when implementing and assessing such programs have hindered the possibility of verifying the effectiveness of this practice as a means to mitigate or eliminate the poaching of jaguars as they interfere with human activities. Just as many researchers stated during the review, the relocation of problem animals is a tool that

requires further evaluation. As long as there are no results on the impact of these types of measure, we will not know whether they are adequate or need to be improved or replaced by more effective ones.

6.2 Implications for research:

The results from the present review indicate a need to develop well designed researches that yield basic data on the jaguar, which would in turn help to make better decisions and implement effective conservation programs.

Quantitative data from well designed and randomized experiments are needed to evaluate the effectiveness of the translocation of problem animals as a conservation strategy. These data must come from the study of variables such as number of jaguars hunted due to conflicts with human activities in capture and released areas, number of reported domestic animals preyed by jaguars, number of jaguars in conflict area, survival of relocated jaguars, among the most important. On the other hand, evaluate the humans' perception towards the jaguar as a competitor and as a potential conflict source, are useful to determine the acceptance of the proposed intervention. Experimental controls must be included in the study designs, establishing temporal comparisons (before and after the relocation of problem animals) and/or spatial comparators (areas with animal relocation problems and areas without conservation measure) for the variables defined above.

A management or relocation program geared toward problem jaguars or any other species should have access to a store of knowledge about the biology and ecology of that particular animal in all its regions of distribution. In the case of the jaguar, the amount of basic knowledge is still insufficient. Besides generating new scientific knowledge, researching should eventually be seen as one of the pillars of jaguar conservation and follow-up programs. However, it is necessary to initiate studies in which information is collected to evaluate conservation strategies. To reinforce the connection between research and conservation programs is critical.

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10. APPENDICES

Appendix 1:

List of studies that were included in the review

1. Hoogesteijn, R., 2003. Manual Sobre Problemas de Depredación Causados por Jaguares y Pumas en Hatos Ganaderos, 39. Wildlife Conservation Society.
2. Hoogesteijn, R., Hoogesteijn, A. and Mondolfi, E., 1992. El dilema depredación vs. conservación del jaguar y análisis de la mortalidad de bovinos causada por felinos en tres hatos del llano venezolano. In *Felinos de Venezuela: biología, ecología y conservación*. ed. Anon, pp. 129-160. Fundación para el desarrollo de las ciencias físicas, matemáticas y naturales (FUDECI), Caracas.
3. Hoogesteijn, R., Boede, E. and Mondolfi, E., 2002. Observaciones de la depredación de bovinos por jaguares en Venezuela y los programas gubernamentales de control. In *El Jaguar en El Nuevo Milenio*. ed. R. Medellín, C. Equihua, C. Chetkiewicz, P. Crawshaw, A. Rabinowitz, K. F. Redford, J. Robinson, E. Sanderson and A. Taber, pp. 183-198. Fondo de Cultura Económica, Universidad Nacional Autónoma de México, Wildlife Conservation Society, México.
4. Medina Padilla, G., Méndez Arocha, J. and Siso Tabares, E., 1992. Alternativas para la preservación y el manejo del yaguar en Venezuela. In *Felinos de Venezuela: biología, ecología y conservación*. ed. FUDECI, pp. 291-299. Fundación para el desarrollo de las ciencias físicas, matemáticas y naturales (FUDECI), Caracas.
5. Mondolfi, E. and Hoogesteijn, R., 1986. Notes on the biology and status of the jaguar in Venezuela. In *Cats of the world: Biology, Conservation and Management*. ed. S. Miller and D. Everett, pp. 125-146. National Wildlife Federation, Washington, D.C.
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8. Rabinowitz, A., 1986. Jaguar predation on domestic livestock in Belize. *Wildlife Society Bulletin* 14, 170-174.
9. Rabinowitz, A. and Nottingham, B., 1986. Ecology and behaviour of the jaguar (*Panthera onca*) in Belize, Central America. *Journal of Zoology* 210, 149-159.

10. Sáenz, J. C. and Carrillo, E., 2002. Jaguares depredadores de ganado en Costa Rica: ¿un problema sin solución? In *El Jaguar en El Nuevo Milenio*. ed. R. Medellín, C. Equihua, C. Chetkiewicz, P. Crawshaw, A. Rabinowitz, K. F. Redford, J. Robinson, E. Sanderson and A. Taber, pp. 127-138. Fondo de cultura económica, Universidad Nacional Autónoma de México, Wildlife Conservation Society, México.

Appendix 2:

Classification of studies' quality according to the criteria set by Pullin and Knight (2001)

| Study | Category | Criteria |
|------------------------------------|-----------------|--|
| Rabinowitz (1986) | II-3 | |
| Rabinowitz & Nottinggam (1986) | II-3 | Conclusive results from uncontrolled experiments |
| Medina Padilla <i>et al</i> (1992) | III | |
| Mondolfi & Hoogesteijn (1986) | III | |
| Mondolfi & Hoogesteijn (1992) | III | Expert opinions based on qualitative field evidence, descriptive studies or expert committee reports |
| Quigley & Crawshaw (1992) | III | |
| Sáenz & Carrillo (2002) | III | |
| Hoogesteijn (2003) | IV | |
| Hoogesteijn <i>et al</i> (2002) | IV | Inadequate evidence due to methodological issues (sample size, duration, etc.) or conflicts relating to unexplainable evidence |
| Hoogesteijn <i>et al</i> (1992) | IV | |

Appendix 3:

Quality assessment of the experimental studies included in the review

| Quality assessment | | |
|--------------------------------------|--|-------|
| Reference: | | |
| Rabinowitz (1986) | | |
| | Characteristic | Score |
| Study design: | | |
| Collecting of samples | Random correct (1) | 1 |
| Sample size | Insufficient (0.5) | 0.5 |
| Use of comparators | With controlled conditions, but no comparator (0.25) | 0.25 |
| Selection of statistical data | Absent (0) | 0 |
| Experimenter's bias | | |
| Population selection | Spatial and temporal autocorrelation (0) | 0 |
| Measures to mitigate selection bias | No (0) | 0 |
| Procedure | Random replication (1) | 1 |
| Measures to mitigate procedural bias | No (0) | 0 |
| Detection of the object of study | With a different probability of being detected (0) | 0 |
| Measures to mitigate detection bias | No (0) | 0 |
| Omission | Open population (0) | 0 |
| Measures to mitigate omission bias | No (0) | 0 |
| Scale of process | Adequate (1) | 1 |
| Scale of experiment | Adequate (1) | 1 |
| Scale of analysis | Inadequate (0) | 0 |
| Overall score | | 4.75 |

| Quality assessment | | |
|--------------------------------|--|-------|
| Reference: | | |
| Rabinowitz & Nottingham (1986) | | |
| | Characteristic | Score |
| Study design: | | |
| Collecting of samples | Random correct (1) | 1 |
| Sample size | Insufficient (0.5) | 0.5 |
| Use of comparators | With comparator and uncontrolled conditions (0.75) | 0.75 |
| Selection of statistical data | Adequate (1) | 1 |

| Quality assessment | | |
|--------------------------------------|--|-------------|
| Reference: | | |
| Rabinowitz & Nottingham (1986) | | |
| | Characteristic | Score |
| Experimenter's bias | | |
| Population selection | Spatial and temporal autocorrelation (0) | 0 |
| Measures to mitigate selection bias | No (0) | 0 |
| Procedure | Random replication (1) | 1 |
| Measures to mitigate procedural bias | No (0) | 0 |
| | With a different probability of being detected (0) | 0 |
| Detection of the object of study | No (0) | 0 |
| Measures to mitigate detection bias | No (0) | 0 |
| Omission | Open population (0) | 0 |
| Measures to mitigate omission bias | No (0) | 0 |
| Scale of process | Adequate (1) | 1 |
| Scale of experiment | Adequate (1) | 1 |
| Scale of analysis | Inadequate (0) | 0 |
| Overall score | | 6.25 |

| Quality assessment | | |
|--------------------------------------|--|-------|
| Reference: | | |
| Sáenz & Carrillo (2002) | | |
| | Characteristic | Score |
| Study: | | |
| Collecting of samples | No random correct (1) | 1 |
| Sample size | Adequate (1) | 1 |
| | With uncontrolled conditions and no comparator (0) | 0 |
| Use of comparators | Adequate (1) | 1 |
| Selection of statistical data | Adequate (1) | 1 |
| Experimenter's bias | | |
| Population selection | Temporal autocorrelation (0.5) | 0,5 |
| Measures to mitigate selection bias | Yes (0.5) | 0.5 |
| Procedure | Without replication (0) | 0 |
| Measures to mitigate procedural bias | No (0) | 0 |
| | With a different probability of being detected (0) | 0 |
| Detection of the object of study | No (0) | 0 |
| Measures to mitigate detection bias | No (0) | 0 |

Quality assessment

Reference:

Sáenz & Carrillo (2002)

| | Characteristic | Score |
|------------------------------------|---------------------|----------|
| Omission | Open population (0) | 0 |
| Measures to mitigate omission bias | No (0) | 0 |
| Scale of process | Inadequate (0) | 0 |
| Scale of experiment | Adequate (1) | 1 |
| Scale of analysis | Inadequate (0) | 0 |
| Overall score | | 5 |

1 **Appendix 4**

2

3 *Qualitative synthesis of the studies included in the review*

| Reference | Country, locality and duration | Objectives | Summary of methods | Main outcomes and conclusions |
|--------------------|---|--|---|---|
| Hoogesteijn (2003) | Latin America / Example case: Venezuela | <p>To provide stockbreeders with tools to understand why felines prey on livestock</p> <p>To analyze previous experiences and outcomes in order to propose several strategies to manage the conflict</p> | <p>By means of a narrative synthesis, the author points out to a series of researches on neotropical felines and their impact on cattle breeding activities</p> <p>Various management alternatives are evaluated, and study results are provided to illustrate cases in which these tools have been used and assessed</p> | <p>In most cases, wild carnivores prey on domestic animals when there is an imbalance in local ecosystems</p> <p>Besides affecting the jaguar itself, the loss of habitat may predispose the feline to prey on livestock.</p> <p>Jaguars prefer closed forests instead of open forests or pastures.</p> <p>Domestic animals, especially bovines, are major components of a jaguar's diet.</p> <p>Problematic jaguars tend to be old, sick animals, and some have been injured by poachers.</p> <p>The annual losses caused by jaguar/feline predation within the cattle-breeding sector are relatively low.</p> <p>The eradication of felines would be seen as an effort to treat the symptoms, but it would not address the root of the problem.</p> <p>Contrary to the belief of many stockbreeders, getting rid of forests does not solve the problem associated with jaguar predation. In fact, such a measure would only prompt one predator to take the place of another (jaguar replaced by puma).</p> <p>Predator control programs are effective in reducing or minimizing predation events only when the problem predator is eradicated. This, however, may be completely useless unless poaching of felines is curbed simultaneously.</p> |

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| Reference | Country, locality and duration | Objectives | Summary of methods | Main outcomes and conclusions |
|---------------------------------|---|--|--|--|
| | | | | <p>According to the paper, 11 jaguars were relocated by PROFAUNA in Venezuela. In most cases, no data were collected regarding the survival of the relocated felines. It was reported that the program had a very local impact.</p> <p>Anti-predator cattle management, compensation, and trophy hunting are presented as alternative ways to solve conflicts.</p> |
| Hoogesteijn <i>et al</i> (1992) | <p>Country: Venezuela</p> <p>Locality: Venezuelan plains (“Llanos”)</p> | <p>To complete a review on the diet of jaguars and the factors that lead these animals to prey on livestock</p> <p>To compare predation events in three cattle farms in the Venezuelan “Llanos”</p> <p>To analyze several proposals aimed at reducing predation events</p> | <p>The authors completed a narrative synthesis with qualitative data from other studies to support it</p> <p>The gathering of data is not explicitly described</p> <p>The authors point out to the relocation program for problematic animals studied by Rabinowitz (1986)</p> | <p>Even though the jaguar feeds on a wide variety of natural preys, cattle and other domestic animals are an important part of the predator’s diet in the Venezuelan “llanos”.</p> <p>Deforestation, rudimentary cattle-breeding management and poaching predispose jaguar to prey upon domestic animals, particularly livestock.</p> <p>According to the analysis of predation incidents that took place in three cattle farms in the Venezuelan “llanos”, several predatory activity patterns were identified. Nevertheless, jaguar predation was not among the major causes of cattle loss, as it only accounted for 9% to 31% of the loss of calves.</p> <p>Cattle management could be employed as a tool to reduce predation events by jaguars and other felines.</p> <p>Relocation does not appear to be the most viable measure to prevent jaguar predation on cattle.</p> <p>The program implemented in Belize and studied by Rabinowitz did not yield positive results, because none of the relocated animals remained in the area for more than three weeks in spite of having access to natural preys.</p> <p>The translocation of a problem jaguar to a place where the animal is able to resume its conflictive</p> |

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| Reference | Country, locality and duration | Objectives | Summary of methods | Main outcomes and conclusions |
|---------------------------------|---|---|--|--|
| | | | | behavior may have a negative impact on cooperation among cattle breeders to protect jaguars. The poaching of problem jaguars needs to be curbed. |
| Hoogesteijn <i>et al</i> (2002) | Country: Venezuela Locality: Venezuelan plains ("Llanos") | To complete a series of reports and observations relating to jaguar predation incidents in cattle breeding areas To point out to solutions to the problem, including those developed by Venezuelan government agencies To report on the outcome of PROFAUNA's jaguar relocation program, the aim of which is to solve conflicts between jaguars and stockbreeders | By means of a narrative synthesis, the authors points out to a series of researches on neotropical felines and their impact on cattle breeding activities The study presents several management alternatives and provides results from cases in which these tools have been used and assessed The authors report on their experience regarding the capture of four problem jaguars The authors report on the results obtained from the program to relocate problematic animals, which PROFAUNA carried out between 1993 and 1998 The results were analyzed in a descriptive manner | Domestic animals, especially bovines, are basic components of a jaguar's diet. Problem jaguars tend to be old, sick animals, and some have been injured by poachers. Annual losses caused by jaguar/feline predation within the cattle-breeding sector are relatively low. The eradication of felines would be seen as an effort to treat the symptoms, but it would not address the root of the problem. Contrary to the belief of many stockbreeders, getting rid of forests does not solve the problem associated with jaguar predation. In fact, such a measure would only prompt one predator to take the place of another (jaguar replaced by puma). Predator control programs are effective in reducing or minimizing predation events only when the problem predator is eradicated. This, however, may be completely useless unless poaching of felines is curbed simultaneously. |

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| Reference | Country, locality and duration | Objectives | Summary of methods | Main outcomes and conclusions |
|-----------|--------------------------------|------------|--------------------|--|
| | | | | <p>The authors captured four jaguars in the states of Cojedes and Falcon. Two of them were taken to a zoo while the other two were relocated to the cattle farm “Hato el Frio”. No follow-up took place to assess the survival of the animals or the impact of relation.</p> <p>PROFAUNA captured 11 jaguars (10 in the state of Cojedes and 1 in Bolivar). The group consisted of 4 males, (3 adults and 1 cub), and 7 adult females. One of the male adults died while being captured. Two were taken to a zoo, where one died during an attack by another jaguar. The other individual was donated to a breeding program belonging to the Jacksonville Zoo in Florida. Four were released without follow-up (the site of release was not specified). A female and its cub were released in the Caura River Forest Reserve, in the Venezuelan state of Bolivar, with radio-transmitting collars, and were followed for 8 months. The female settled in the area of release, whereas the cub separated from the female but remained in the area. Two females were fitted with radio transmitters and released, one in “Hato el Frio” (Apure State), and the other in Aguaro-Guariquito National Park (state of Guarico). The female that was released in “Hato el Frio” was killed by poachers. The one released in the national park was followed for 5 months, period in which the animal remained within the park. According to local cattle farmers, the jaguar has kept preying on livestock, although this has not been confirmed.</p> <p>Anti-predator cattle management, compensation, and trophy hunting are presented as alternative ways to solve conflicts.</p> |

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| Reference | Country, locality and duration | Objectives | Summary of methods | Main outcomes and conclusions |
|------------------------------------|--------------------------------|--|---|--|
| | | | | Private properties could have a great significance in the conservation of jaguar in the Venezuelan “llanos”, but their effectiveness will depend entirely on the attitudes of cattle breeders towards the predator. |
| Medina Padilla <i>et al</i> (1992) | Country: Venezuela | To complete a review on the status of jaguars in Venezuela and on the future of this predator in said country To analyze some of the measures suggested to ensure the conservation of jaguars | The authors assess the status of jaguars in Venezuela by means of a narrative synthesis The authors comment on several potential measures to protect jaguars | Despite the legal framework in place and the efforts of the authorities, the hunting of jaguar in Venezuela is a frequent persistent event. Hunting and loss of habitat are factors that curb the population growth of jaguars in Venezuela. Jaguar populations will grow or at least remain stable if hunting bans are properly enforced, if poaching within protected areas remains under control, and if special reserves are created for jaguars on both sides of the Orinoco River. Implementing educational campaigns and solving conflicts with cattle breeders is also necessary. Although relocation seems to be an adequate option, it demands time and significant funds, and thus cannot be taken into account as an immediate option. Cases of relocation have failed because most felines keep preying upon domestic animals. Controlled hunting is proposed as an alternative measure. |
| Mondolfi & Hoogesteijn (1986) | Country: Venezuela | To compare observations made in Venezuela on the biology of jaguars to those provided by other countries To evaluate and propose managing and research activities aimed at the | This is a narrative synthesis Based on the biology of the jaguar, the authors compare data from Venezuela to that of other countries with jaguar | The status of jaguars in Venezuela is critical. Its distribution has significantly decreased and its populations have diminished in areas where the feline used to live in large numbers. Conservation measures must be aimed at protecting jaguar populations and its habitat. |

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| Reference | Country, locality and duration | Objectives | Summary of methods | Main outcomes and conclusions |
|-------------------------------|--------------------------------|---|---|--|
| | | conservation of jaguars | populations. Included are basic characteristics, habitat, behavior, diet, reproduction, and population status The authors propose measures to implement a conservation program | Loss of habitat and illegal hunting are the jaguar's main sources of threat. The areas where jaguar populations have been severely impacted are the plains or "llanos", the foothills of the coastal mountain range, the basin of the Maracaibo Lake and the state of Bolivar. Jaguar may be effectively protected in some of the country's largest national parks. Research and controlled hunting are the main conservation measures suggested. The relocation of problematic animals must take place under heavily controlled conditions. This measure does not guarantee the end of human-predator conflicts. |
| Mondolfi & Hoogesteijn (1992) | Country: Venezuela | To evaluate and propose managing and research activities aimed at the conservation of jaguars | By means of a narrative synthesis, the authors assess and recommend measures for a program to protect jaguar in Venezuela | The status of jaguars in Venezuela is critical. Its distribution has significantly decreased and its populations have diminished in areas where the feline used to live in large numbers. Conservation measures must be aimed at protecting jaguar populations and its habitat. Loss of habitat and illegal hunting are the jaguar's main sources of threat. The areas where jaguar populations have been severely impacted are the plains or "llanos", the foothills of the coastal mountain range, the basin of the Maracaibo Lake and the state of Bolivar. Jaguars may be effectively protected in some of the country's largest national parks. Research and controlled hunting are the main conservation measures suggested. The relocation of problematic animals must take |

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| Reference | Country, locality and duration | Objectives | Summary of methods | Main outcomes and conclusions |
|---------------------------|---|---|--|--|
| Quigley & Crawshaw (1992) | Country: Brazil Locality: The Pantanal | To report on the status of jaguars in the Pantanal To propose a management plan that includes suggestions for the development of wildlife reserves and the management of livestock predation conflicts | This narrative paper uses quantitative data to reinforce the authors' arguments The authors use up-to-date biological information | place under heavily controlled conditions. This measure does not guarantee the end of human-predator conflicts. The status of jaguar populations in the Pantanal area is unstable. Isolation and habitat loss are considered as major sources of extinction. The Pantanal National Park is the only protected area that is not adequately managed and does not meet the requirements, in terms of its size, for the conservation of jaguars. Privately-owned areas represent 95% of the territory. The protection of jaguars beyond the protected area depends on land owners' perceptions of the predator. Unstable cattle breeding activities favor jaguar predation on livestock, although this is not the main cause of cattle loss in the area. The flood regime and the inaccessibility of certain areas have allowed for the conservation of jaguars in privately-owned stretches of land. All management practices must focus on maintaining minimum populations of jaguars. The authors recommend the creation of a vast expanse for reserves (2,000 - 3,000 sq. Km). The creation of environmental corridors to connect natural areas is recommended. Improving control measures over cattle breeding would drive down loss of livestock due to predation incidents. The authors believe in eliminating problematic animals as a possible way to resolve conflicts. One alternative is relocating the animal, though further studies are needed, according to the authors, |

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| Reference | Country, locality and duration | Objectives | Summary of methods | Main outcomes and conclusions |
|-------------------|---|---|---|---|
| | | | | in order to verify the effectiveness of such a measure. The authors also point out to other options such as ecotourism, environmental education and the creation of wildlife reserves. |
| Rabinowitz (1986) | Country: Belize Locality: Cockscomb Basin Duration: 3 years (1983-1985) | To research on jaguar/livestock interaction To provide assistance to the government of Belize in the development of a management program aimed at controlling livestock predation events | Five male jaguars and two sub-adults individuals, one male, one female, were captured. The former group is considered non-conflictive, whereas the latter is considered conflictive All individuals were fitted with radio transmitting collars so they would be traced. The follow-up period varied with each animal The individuals were classified by age and behavior During the follow-up, activity data were collected three times a week The health of each individual was evaluated Results were presented in a descriptive manner | Despite the fact that local jaguars were active near pasture areas and indigenous settlements, no livestock predation incidents were reported. The only cases detected of domestic animal predation by jaguars were those in which the former left an open field to go into a forest area. The cases of hunted jaguars were associated with individuals that went into pasture areas to prey on livestock. Ten out of thirteen jaguars killed due to conflicts had malformations and injuries to the head and body, many of them caused by a firearm. Of the two relocated individuals, the female was spotted close to cattle breeding grounds and started to prey on livestock (2 calves). Because of this, it was hunted down and killed five weeks after being relocated. The sub-adult male remained within the area of release, but eventually left and could not be spotted again. In some places, relocation seems to be the least viable technique. The protection of forest areas and the implementation of management practices seem to be the best alternatives for the conservation of |

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| Reference | Country, locality and duration | Objectives | Summary of methods | Main outcomes and conclusions |
|-------------------------------|--|---|--|---|
| Rabinowitz & Nottingam (1986) | Country: Belize Locality: Cockscomb Basin | To research into the biology of the jaguar To compare data from local jaguars to that of jaguar that were relocated due to conflicts with stockbreeding activities | Four jaguars were caught by using traps and tracking dogs. The felines were fitted with radio transmitters for tracking purposes A relocated sub-adult female was followed up after being involved in a predation event The locations were used to establish the animal's range and were evaluated by taking land uses into account Animal activity was studied every 15 minutes during a 24-hour period. Chi-square tests were used to establish patterns Researchers traveled in order to track unidentified jaguars and used traces to determine their range and habitat use. Feces samples were collected to study the animal's diet, and chi-square tests were carried out to assess temporal variations A cranial morphometric study was carried out in order to characterize the age of the individuals | jaguars. The range of 4 non-livestock predator male adults that were followed for 3 to 14 months registered 22.4 km ² (28 – 40 km ² , SD 5.5 km ²). Two unidentified females that were studied through their traces registered ranges of 10 km ² and 11km ² . A relocated problem female registered a range of 10 km ² . The range of females did not overlap and was always within that of males. The range of males registered an overlapping of up to 50%. Feces were more likely to be found in areas of territory overlapping. Male jaguars tended to be more nocturnal and usually rested at midday. The problem female displayed a diurnal pattern of activity when it began to prey on cattle. 17 preys were identified as components of a jaguar's diet, being the armadillo the most important one. The differences in the patterns of activity of problem males and females are associated with the type of prey. Cattle are basically diurnal preys, whereas armadillos (an important component of a |

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| Reference | Country, locality and duration | Objectives | Summary of methods | Main outcomes and conclusions |
|-----------------------|---|--|---|--|
| Sáenz Carrillo (2002) | & Country: Costa Rica Duration: 7 years according to records (1991-1998) | To assess livestock predation incidents caused by jaguars, as well as their impact on cattle breeding activities To determine the status of jaguars in the country and provide solutions for their conservation | Reported incidents were studied at the National System of Conservation Areas (SINAC) to determine the sites where jaguar preyed on domestic animals A form was designed for directors of conservation areas to collect information regarding the location of an event, the age and sex of the jaguar and the type and number of domestic animals that were preyed upon Phone calls made to National University's Wildlife Program to file complaints were reviewed and the callers were interviewed The reports were analyzed using descriptive statistics, and by taking into account each record only once | non-problem jaguar) are mostly nocturnal. Jaguar attacks on livestock were reported in 47 localities. The Central Range, the north and northeast of the country were the areas with the most incidents. In the cases that were reported, 64.1% involved male adults, 15.6% involved female adults with cubs, and 20.3% involved sub-adults. Of the cattle ranches that were attacked, around 87% were located within 15 kilometers of a protected area. 72.3 % of the attacks took place in open pastures, 13.2 % in scrubland, 8.1 % in secondary forests, and 6.4 % in dense forests. The authors believe that the number of sacrificed jaguars (21 sacrificed and 2 captured) and cattle predation events (22 attacks a year) are only a fraction of what actually takes place. Even though protected areas are effective tools to protect jaguars and avoid conflicts, the measure seems unrealistic due to the size of the territory that would be needed. The traditional management of cattle may favor the occurrence of predation. Compensating cattle farmers for their losses could turn out to be an effective strategy in Costa Rica. Sport hunting could hinder the conservation of these felines. Besides being expensive, relocation does not seem |

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| Reference | Country, locality and duration | Objectives | Summary of methods | Main outcomes and conclusions |
|-----------|--------------------------------|------------|--------------------|---|
| | | | | <p>to be a very effective practice. However, the authors believe that it needs to be further tested before it is discarded definitely as a measure.</p> <p>Creation of protected areas, improvement of cattle management, environmental education and other practices that were mentioned before are medium to long term strategies. It is therefore necessary to adopt quick measures to tackle the causes of jaguar mortality.</p> <p>The authors also suggest the use of collars with systems that rely on light or sound to stun problem jaguars as a means to reduce predation on livestock.</p> |

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5
6

7 **Appendix 5**

8

9 *Sources of heterogeneity among the studies included in the review*

| Sources of heterogeneity I | | | | | | | |
|---|------------------------------|--------------------------|---|------------------------------------|--|--|---|
| Ecological factor and species characteristics: | | | | | | | |
| <i>Study</i> | <i>Region or locality</i> | <i>Surface</i> | <i>Habitat</i> | <i>Presence of other predators</i> | <i>Local threats to the jaguar</i> | <i>Age, sex and health of individuals</i> | <i>Behavior</i> |
| Hoogesteijn (2003) | Latin America: Venezuela | Does not specify | Floodable savanna (The “Llanos”) | Pumas and other predators | Conflict-related hunting and loss of habitat | Does not mention | Relocated animals display problematic behavior |
| Hoogesteijn <i>et al</i> (1992) | Venezuelan plains | Does not specify | Floodable savanna (The “Llanos”) | Pumas and other predators | Conflict-related hunting and loss of habitat | 11 individuals: 7 female adults, 3 male adults and 1 male cub | Conflicts between some relocated animals and cattle breeding activities |
| Hoogesteijn <i>et al</i> (2002) | Venezuelan plains and Belize | Does not specify | Floodable savanna (The “Llanos”), and protected area (Belize) | Pumas and other predators | Conflict-related hunting and loss of habitat | Belize: 2 individuals (1 young female and 1 sub-adult male) | Relocated animals display problematic behavior |
| Medina Padilla <i>et al</i> (1992) | Venezuela | Does not specify | Entire territory | Pumas and other predators | Conflict-related hunting and loss of habitat | Does not specify | Only problem animals should be relocated |
| Mondolfi & Hoogesteijn (1986) | Venezuela | Does not specify | Entire territory | Pumas and other predators | Conflict-related hunting and loss of habitat | Does not specify | Only problem animals should be relocated |
| Mondolfi & Hoogesteijn (1992) | Venezuela | Entire territory | Does not specify | Pumas and other predators | Conflict-related hunting and loss of habitat | Does not specify | Only problem animals should be relocated |
| Quigley & Crawshaw (1992) | The Pantanal, Brazil | 100000 km ² . | Floodable savanna within The Pantanal | Pumas and other predators | Conflict-related hunting and loss of habitat | Does not specify | Only problem animals should be relocated |
| Rabinowitz (1986) | Cockscomb Basin, Belize | 425 km ² . | Bosque subtropical | Does not specify | Conflict-related hunting | One sub-adult female with malformations and one sub-adult male | Problem female. Male’s behavior is not specified |
| Rabinowitz & Nottingam | Cockscomb Basin, Belize | 425 km ² . | Bosque subtropical | Puma | Conflict-related hunting | Female with malformations | |

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Sources of heterogeneity I

| Ecological factor and species characteristics: | | | | | | | |
|---|---------------------------|------------------|------------------|------------------------------------|--|---|------------------|
| <i>Study</i> | <i>Region or locality</i> | <i>Surface</i> | <i>Habitat</i> | <i>Presence of other predators</i> | <i>Local threats to the jaguar</i> | <i>Age, sex and health of individuals</i> | <i>Behavior</i> |
| (1986) | | | | | | | |
| Sáenz & Carrillo (2002) | Costa Rica | Entire territory | Does not specify | Puma | Conflict-related hunting and loss of habitat | Does not specify | Does not specify |

Sources of heterogeneity II

| Method of identification, capture, relocation and release of problematic animals | | | | | | | |
|---|---|--|---|--|---|--|--|
| <i>Study</i> | <i>Techniques for the follow-up and identification of problem animals</i> | <i>Degree of conflict between man and jaguar</i> | <i>Capture, relocation and release methods</i> | <i>Selection of release areas</i> | <i>Protection, management and follow-up of relocated jaguar</i> | <i>Duration and continuity of relocation program</i> | <i>Researcher's level of expertise</i> |
| Hoogesteijn (2003) | The author suggests following tracks, searching for predated cattle and using dogs to work with confirmed traces of problematic animals | Frequent conflicts with cattle breeding activities | Trained dogs and tranquilizer dart rifles. No details on relocation. | Does not specify | Does not specify | 1993-1998 (6 years) | PROFAUNA, and hunting specialists |
| Hoogesteijn <i>et al</i> (1992) | Does not specify | Does not specify | In some instances, baited traps were used (goats and dogs). Other cases required the use of hunting dogs and tranquilizer dart rifles | In the mentioned cases, the animals were released in estates with conservation management practices or protected areas | Four individuals were followed using radio transmitters for at least one year | 1993-1998 (6 years) | PROFAUNA, and hunting specialists |
| Hoogesteijn <i>et al</i> | Does not specify | Does not specify | Does not specify | Protected area | Follow-up was | Does not specify | Rabinowitz, |

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Sources of heterogeneity II

| Method of identification, capture, relocation and release of problematic animals | | | | | | | |
|---|---|--|--|--|--|--|--|
| <i>Study</i> | <i>Techniques for the follow-up and identification of problem animals</i> | <i>Degree of conflict between man and jaguar</i> | <i>Capture, relocation and release methods</i> | <i>Selection of release areas</i> | <i>Protection, management and follow-up of relocated jaguar</i> | <i>Duration and continuity of relocation program</i> | <i>Researcher's level of expertise</i> |
| (2002) | | | | | carried out but there are no details on how | | researcher with feline expertise |
| Medina Padilla <i>et al</i> (1992) | Telemetry | Does not specify | Traps or tranquilizer dart rifles | Large wildlife reserve with adequate habitats, healthy prey populations and effective management to prevent poaching | Proposed | Proposed | The assembly of a qualified work team is advised |
| Mondolfi & Hoogesteijn (1986) | Does not specify a need for follow-up | Does not specify | Traps or alternative methods | Does not specify | Does not specify | Does not specify | Does not specify |
| Mondolfi & Hoogesteijn (1992) | Does not specify a need for follow-up | Does not specify | Traps or alternative methods | Does not specify | Does not specify | Does not specify | Does not specify |
| Quigley & Crawshaw (1992) | Does not specify | Does not specify | Does not specify | Does not specify | Does not specify | Does not specify | Does not specify |
| Rabinowitz (1986) | Does not specify | Does not specify | Does not specify | Does not specify | Telemetry. Individuals were relocated far from humans and other jaguar | 1983-1985 (3 years) | Biologists (feline specialists) |
| Rabinowitz & Nottingam (1986) | Does not specify | Does not specify | Does not specify | Does not specify | Telemetry. Individuals were relocated far from humans and other jaguar | 1983-1985 (3 years) | Biologists (feline specialists) |
| Sáenz & Carrillo (2002) | Does not specify | Does not specify | Does not specify | Does not specify | Does not specify | Does not specify | Does not specify |

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| Sources of heterogeneity III | | | | | | | |
|------------------------------------|--|---|---|--|--|---|--|
| Social and institutional factors | | | | | | | |
| <i>Study</i> | <i>Cultural value of the jaguar</i> | <i>Stakeholders</i> | <i>Land use</i> | <i>Environmental education and support for the program</i> | <i>Support from experts and researchers</i> | <i>Institutional support and funding</i> | <i>Ethical values</i> |
| Hoogesteijn (2003) | Does not specify | Cattle raisers, and government | Extensive cattle breeding | Not implemented | Does not specify | Funding was provided by American hunters that belong to the Safari Club | Concern due to unregulated hunting activities, economic loss among cattle breeders, and environmental disturbances Concern due to unregulated hunting activities, economic loss among cattle breeders, and environmental disturbances |
| Hoogesteijn <i>et al</i> (1992) | Does not specify | Cattle raisers, and government | Extensive cattle breeding | Does not specify | The authors engaged in the program | Does not specify | Concern due to unregulated hunting activities, economic loss among cattle breeders, and environmental disturbances |
| Hoogesteijn <i>et al</i> (2002) | Does not specify | Cattle raisers, and indigenous communities | Cattle breeding and wildlife preservation | Does not specify | Rabinowitz, researcher with feline expertise | Does not specify | Does not specify |
| Medina Padilla <i>et al</i> (1992) | Does not specify | Cattle raisers, government, and protected area managers | Mostly cattle breeding | Proposed as an alternative measure | Does not specify | Institutional support for the creation of a compensation fund | Concern due to unregulated hunting activities, and predation on livestock |
| Mondolfi & Hoogesteijn (1986) | The jaguar is an important predator and should be seen as a symbol | Does not specify | Cattle breeding | Does not specify | Does not specify | Does not specify | Does not specify |
| Mondolfi & Hoogesteijn | The jaguar is an important predator | Does not specify | Cattle breeding | Does not specify | Does not specify | Does not specify | Does not specify |

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| Sources of heterogeneity III | | | | | | | |
|---|-------------------------------------|--|---|--|---|--|-----------------------|
| Social and institutional factors | | | | | | | |
| <i>Study</i> | <i>Cultural value of the jaguar</i> | <i>Stakeholders</i> | <i>Land use</i> | <i>Environmental education and support for the program</i> | <i>Support from experts and researchers</i> | <i>Institutional support and funding</i> | <i>Ethical values</i> |
| (1992) | and should be seen as a symbol | | | | | | |
| Quigley & Crawshaw (1992) | Does not specify | Cattle raisers, government, and protected area managers | Mostly cattle breeding | Proposed as an alternative measure | Does not specify | Does not specify | Does not specify |
| Rabinowitz (1986) | Does not specify | Cattle raisers, farmers, and indigenous people | Cattle breeding, farming, and wildlife protection | Does not specify | Does not specify | Does not specify | Does not specify |
| Rabinowitz & Nottingam (1986) | Does not specify | Cattle raisers, farmers, and indigenous people | Cattle breeding, farming, and wildlife protection | Does not specify | Does not specify | Does not specify | Does not specify |
| Sáenz & Carrillo (2002) | Does not specify | Cattle raisers, land owners, and protected area managers | Cattle breeding, farming, and wildlife protection | Proposed as an alternative measure | Does not specify | Does not specify | Does not specify |

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16 **Appendix 6**

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18 *Summary table on problem jaguar relocation programs*

| Study | Country | Site of capture | Method of capture | Age | Sex | Area of release | Follow-up | Survival of relocated jaguar | Predator behavior |
|--|-----------|--|-------------------|-----------|--------|---|-------------------|------------------------------|------------------------|
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Cojedes State, Tinaco River, "Hato Corocito" cattle ranch | Trap | Old adult | Male | Zoo | | | Predation on livestock |
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Cojedes State, Tinaco River, "Hato Corocito" cattle ranch | Trap | | | Dead | | Dead | |
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Falcon State, Boca de Aroa, "Hacienda Casablanca" cattle ranch | Trap | Old adult | Female | Zoo | | | Predation on livestock |
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Falcon State, Boca de Aroa, "Hacienda Casablanca" cattle ranch | Trap | Adult | Male | Hato el Frio, Apure | Not carried out | | Unknown |
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Falcon State, Boca de Aroa, "Hacienda Casablanca" cattle ranch | Trap | | Female | | Not carried out | | |
| Hoogesteijn R, Boede E. | Venezuela | Cojedes State, "Hato | | Adult | Female | Caura River Forest Reserve, Bolívar State | Radio transmitter | At least 8 months | Predation on livestock |

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| Study | Country | Site of capture | Method of capture | Age | Sex | Area of release | Follow-up | Survival of relocated jaguar | Predator behavior |
|--|-----------|-----------------------------|--|-----|--------|---|-------------------|------------------------------|-------------------|
| and Mondolfi E. (2002) | | Paraima” cattle ranch | | | | | | | |
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Cojedes State, Tinaco River | | Cub | Male | Caura River Forest Reserve, Bolívar State | Radio transmitter | At least 8 months | |
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Cojedes State, Tinaco River | Hunting specialist, hunting dogs and tranquilizers | | Female | | Not carried out | | |
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Cojedes State, Tinaco River | Hunting specialist, hunting dogs and tranquilizers | | Female | | Not carried out | | |
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Cojedes State, Tinaco River | Hunting specialist, hunting dogs and tranquilizers | | Female | | Not carried out | | |
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Cojedes State, Tinaco River | Hunting specialist, hunting dogs and tranquilizers | | Female | | Not carried out | | |
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Cojedes State, Tinaco River | Hunting specialist, hunting dogs and tranquilizers | | Female | “Hato el Frio” cattle ranch, Apure State | Radio transmitter | Dead | |
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Cojedes | Hunting | | Female | Aguaro-Guariquito | Radio | At least 5 | Predation on |

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| Study | Country | Site of capture | Method of capture | Age | Sex | Area of release | Follow-up | Survival of relocated jaguar | Predator behavior |
|--|-----------|-----------------------------|--|-----------|--------|------------------------------|-------------------|------------------------------|------------------------|
| R, Boede E. and Mondolfi E. (2002) | | State, Tinaco River | specialist, hunting dogs and tranquilizers | | | National Park, Guarico State | transmitter | months | livestock |
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Cojedes State, Tinaco River | Hunting specialist, hunting dogs and tranquilizers | | Male | Dead | | Dead | |
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Cojedes State, Tinaco River | Hunting specialist, hunting dogs and tranquilizers | | Male | Zoo | | | |
| Hoogesteijn R, Boede E. and Mondolfi E. (2002) | Venezuela | Cojedes State, Tinaco River | Hunting specialist, hunting dogs and tranquilizers | | Male | Zoo | | | |
| Rabinowitz A. (1986) | Belize | Northern Belize | Traps or hunting dogs | Adult | Female | Cockscomb Reserve | Radio transmitter | 5 weeks | Predation on livestock |
| Rabinowitz A. (1986) | Belize | Northern Belize | Traps or hunting dogs | Sub-adult | Male | Cockscomb Reserve | Radio transmitter | At least 3 weeks | |

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20 **Appendix 7:**

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22 *List of studies that were not included in the review*

23

24 1. Anon, 2000. Save the jaguar. *Wildlife Conservation* 103(6), 10.

25

26 2. Anon, 2006. Borderlands Conservation Strategy for the Northern Jaguar - Working
27 Draft. Jaguar Conservation Team.

28

29 3. Gonzalez-Fernandez A., 1991. Depredacion de ganado por yaguares y pumas en los
30 llanos de los estados Cojedes y Portuguesa: frecuencia, factores predisponentes y
31 consecuencias. Universidad Nacional Experimental de los Llanos Occidentales
32 Ezequiel Zamora. Guanare, Venezuela.

33

34 4. Hoogesteijn R., Mondolfi E. and Michelangeli A., 1986. Observaciones sobre el
35 estado de las poblaciones y las medidas para la conservación del jaguar en
36 Venezuela. Symposium International Conservation Status of the Jaguar, 31-75.

37

38 5. Jackson P. and des Clers B., 1986. Conclusions on the conservation status of the
39 jaguar. In *Conservation status of the jaguar (Panthera onca)*. ed. B. des Clers. pp. 91-
40 94. Conseil International de la Chasse et de la Conservation du Gibier. Paris, France.

41

42 6. Johnson T. B. and Van Pelt W. E., 1997. Conservation assessment and strategy for
43 the jaguar in Arizona and New Mexico. Program Technical Report. Wildlife
44 Management Division, Arizona Game and Fish Department, Fish and Wildlife
45 Service, New Mexico Department of Game and Fish. Arizona.

46

47 7. McCarthy T., Dorfman A., Booth Thomas C. and Robinson S., 2004. Nowhere to
48 roam. *Time* 164(8), 44-53.

49

50 8. Mondolfi E. and Hoogesteijn R., 1986. Suggestions for a conservation strategy for
51 the jaguar in Venezuela. Fundación para la Defensa de la Naturaleza (FUDENA).
52 Caracas, Venezuela.

53

54 9. Musgrave M. E., 1921. Predatory animals in Arizona. *American Game Protective
55 Association Bulletin* 10, 11-12.

56

57 10. Silver S. C., 2004. Jaguar Conservation Program's Initial Response Protocol for
58 Problem Felids. WCS Jaguar Conservaiton Program. Wildlife Conservation Society.

59

60

61 **Appendix 8:**

62

63 *List of studies without full text available and not included in the review*

64

65 1. Gonzalez-Fernandez A. J., 1995. Livestock predation in the Venezuelan Llanos. *Cat*
66 *News* 22, 14-15.

67

68 2. Jackson P., 1990. Jaguars and livestock. *Cat News* 13(13).

69

70 3. Medina Padilla G., Méndez Arocha J. L. and Tabares E. S., 1991. El yaguar en
71 Venezuela, alternativas para su preservación y manejo. *Profauna* 1, 3-5.

72

73 4. Rabinowitz A., 1986. Jaguar predation on domestic livestock in Belize. *Belize*
74 *Audubon Society Bulletin* 18, 1-5.

75

76 5. Rabinowitz A., 1992. Jaguar conflict and conservation: a strategy for the future. In
77 *Integrating people and wildlife for a sustainable future*. ed. J. A. Bissonette and P. R.
78 Krausman. pp. 394-397. The Wildlife Society. Bethesda, Maryland, USA.

79

80 6. Tello J. L., 1986. The situation of the wild cats (Felidae) in Bolivia including notes
81 on other wildlife species and on general aspects of the conservation and utilization of
82 natural resources. *Convention In Trade of Endangered Species*. Secretariat CITES.
83 Lausanne, Switzerland.

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