CONSERVING CARNIVORES:

A. Attitudes of Portuguese high school students towards carnivores.

B. Feeding habits of the jaguar: local and regional perspectives.

By

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ABSTRACT

Carnivores play a crucial role as an essential component of ecosystems, yet most of the species are currently threatened by factors such as habitat loss, prey depletion and human persecution.

Application of human dimensions research to carnivore conservation has increasingly been recognized as of the utmost importance, in order to understand and minimize human-carnivore conflict. Attitudes of Portuguese high school students towards carnivores were thus assessed by a written questionnaire survey. This study aimed to identify what factors most influenced high school students' levels of acceptance and support for carnivore conservation, such as geographic region (relative carnivore abundance), socio-demographic factors, level of fear, knowledge or previous conflict with carnivores. This target group had very positive attitudes towards carnivores and their conservation, but a general feeling of fear was found among them. Knowledge about carnivore species was generally low. Source of information, interest about wildlife, frequency of close contact with nature and socio-demographic factors were the variables that best explained variation between students. A positive correlation was found between knowledge and attitudes. Recommendations on how to increase acceptance of carnivores are given.

To provide a better insight into the feeding habitats of the jaguar *Panthera onca,* a large predator which is mainly threatened by habitat loss and human persecution, its food habits and prey selectivity were assessed in Cantão State Park, Brazil, a protected area in the Amazon Basin. Food habits were determined from analysis of 25 scats, and jaguar diet in terms of consumed biomass was dominated by tapirs, peccaries, and cattle calves, whilst the most frequent prey were opossums, peccaries and monkeys. Prey selectivity, based on information from camera trapping, indicates that jaguars might be positively selecting anteaters in this study area. The geographical variation in the jaguar diet was also analysed from review of studies in several locations along its range, and although this species shows a great diversity in feeding ecology, habitat type and latitude seem to be important factors explaining jaguar diet variability. Implications for jaguar conservation are discussed.

Key words: attitudes, carnivores, diet, human dimensions, jaguar, wildlife management.

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INTRODUCTION

Carnivores play a crucial role as an essential component of ecosystems. The extinction of animals like the grizzly bear (*Ursus arctos*) and wolf (*Canis lupus*) from certain areas of North America has resulted in significant alterations in prey communities, either in structure or in behaviour (Berger 1999). Besides predation, carnivores also exert a profound influence on communities aiding seed dispersal (Willson 1993), and through interspecific competition (Caro & Stoner 2003)

Despite their relevant ecological importance, carnivores have been target species in human-wildlife conflict due to the impact of predation on agricultural and fisheries interests, interaction with hunters and fishermen through competition for game and aquatic resources, and general fear and anxiety for personal safety (Sillero-Zubiri *et al*. 2004). Another reason for human-carnivore conflict is the diseases brought to people and domestic animals (Woodroffe *et al.* 2004).

As a result of such conflicts, carnivores have been subject of persecution that, along with the growth of human populations and associated impacts such as habitat loss and the spread of invasive species, has caused declines of virtually all mammal species (Cardillo *et al.* 2004).

Being impact by humans one of the greatest threats to carnivore survival, Chapter A presents a study aimed at understanding Portuguese students' perceptions, and attitudes regarding carnivores and their conservation. Attitudes towards wildlife and nature conservation has been the subject of several studies in the past two decades, and application of human dimensions research to carnivore conservation has increasingly been recognized as a priority (Sillero-Zubiri *et al.* 2004).

The conservation of carnivores ultimately depends on assessing their distribution and abundance, and acting accordingly to its situation. A essential prerequisite is evaluating prey use and availability, because carnivore populations are generally understood to be a reflection of prey resources (Fuller & Sievert 2001). Therefore, Chapter B presents a study on the feeding ecology at a local and regional scale of a large predator: the jaguar *Panthera onca,* which is mainly threatened by habitat loss and human persecution due to attacks on livestock (IUCN 2006).

For each chapter, introduction, methods, results and discussion are presented. A short general discussion is finally presented.

CHAPTER A

"Attitudes of Portuguese high school students towards carnivores"

A1. Introduction

Human-wildlife conflict is a widespread conservation problem, and its minimization has increasingly been recognized as of the utmost importance (Woodroffe *et al*. 2005). Due to their large spatial requirements, the long-term viability of many carnivore species cannot be ensured by protected areas alone (Woodroffe & Ginsberg 1998). Thus, carnivore survival requires persistence in multi-use areas where they are especially prone to come into conflict with human populations (Treves & Karanth 2003). As a consequence, and also due to innate human prejudice (Kruuk 2002), carnivores have frequently been seen as vermin, vilified by people and actively sought out and killed (Sillero-Zubiri *et al.* 2004).

It has been suggested that modification of behaviour (either of humans, carnivores, or target prey) can provide a solution to human-carnivore conflict, minimizing unwanted interactions (Treves & Karanth 2003). Therefore, the answer to this problem does not only rely on wildlife management and nature conservation – carnivore conservation is a sociological issue as well a biological one (Bath 2000). An example is the wolf reintroduction programme at Yellowstone National Park (USA), where carnivore management has passed through several stages, each reflecting national attitudes (Schullery & Whittlesey 1999). Similar processes have occurred regarding all the European large terrestrial carnivores such as brown bears, wolves and lynxes. From unprotected pests, whose eradication was often encouraged, they have become protected wildlife (Treves & Karanth 2003).

Human dimensions research in wildlife management focuses on understanding how people value wildlife, on evaluating public support or opposition to management actions, and on involving people who are affected by wildlife decisions (Decker *et al.* 2001). Since without human tolerance from the different interest groups it will be difficult to achieve conservation and recovery of carnivore populations, studies of public opinion and knowledge have become important elements of carnivore conservation management. Qualitative and quantitative approaches have been used to analyse attitudes towards carnivores in several European countries including Italy (Dupré *et al*. 1998), France (Bath 2000), United

Kingdom (Bath & Farmer 2000), Croatia (Bath & Majić 2001), Latvia (Andersone & Ozolins 2002), Slovenia (Kaczensky *et al.* 2004), Austria (Kaczensky 2003) and Switzerland (Kaczensky 2003).

In spite of the relevance of human attitudes for carnivore conservation, it still remains regarded as unimportant in Portugal, where the input of the public's views, concerns or needs is rarely considered in wildlife management (Espirito-Santo & Petrucci-Fonseca 2004). Similarly to most countries, which have focused mainly on large carnivores (e.g. Bath 2000, Kaltenborn & Bjerke 2002), the only two human dimensions studies published both concern the wolf (Álvares *et al.* 2000, Espirito-Santo & Petrucci-Fonseca 2004). Indeed there is a considerable amount of research documenting public attitudes towards wolves (for a review of 38 surveys see Williams *et al.* 2002) but attitudes towards mesocarnivores or carnivores as a community have rarely or never been assessed (some exceptions are a study of attitudes towards blackfooted ferret (*Mustela nigripes*) reintroduction by Reading and Kellert (1993), and an assessment of attitudes in relation to the European Polecat (*Mustela putorius)* by Packer and Birks (1999)).

Yet, as stated by Kruuk (2002), "similarities, whether real or perceived, are the base for our prejudices", and for understanding the human relationship with carnivores the similarity between species may be important, because our experience with one carnivore is likely to affect our behaviour towards others (Kruuk 2002). In addition, most of the Portuguese species are mesocarnivores, and even if they are not presently threatened, pre-emptive conservation action is often preferable and studies on such species are important since, unlike the more prominent large carnivores, their populations can decrease with little notice (Zielinski 2004).

The development of human attitudes towards wildlife is a complex process influenced by economic, social–psychological and biological factors (Gray 1993). People that hold a strong positive attitude towards carnivores will most likely support actions favourable to carnivores (Bright & Manfredo 1995). Therefore, understanding which factors influence attitudes is key to choosing and targeting the most appropriate solutions, whether mitigation to reduce losses (Ogada *et al*. 2003), education to improve awareness (Marker *et al*. 2003), or benefit generation to provide incentives (Mishra *et al*. 2003). For example, although urban citizens are generally in favour of carnivore conservation, the direct costs of conserving these animals fall on a minority of individuals in rural areas who lose livestock or pets to

carnivores (Naughton-Treves *et al.* 2003). Thus, several studies have reported negative attitudes towards wild carnivores among rural residents in many regions of the world (e.g. Oli *et al.* 1994, Mech 1995). Socio-demographic characteristics such as age, sex, and education, as well as knowledge and fear, have also been shown to be important factors influencing attitude to and acceptance of species such as wolves, bears and lynxes (Kaczensky 2003). Generally, females and people living in the carnivore distribution range tend to be more negative than their respective counterparts (Bath 1991, Kellert *et al.* 1996).

Despite the fact that, in the last 50 years, Portugal has witnessed significant changes in the economic and social structures, rural areas still make up 92.7% of the territory, with 46.3% being used by agriculture, 26.4% by forests and 20.0% as natural public parks (MADRP 2006). The pattern of distribution of the human population shows a high concentration on coastal regions, especially to the North of Lisbon and in the Metropolitan Area of Lisbon, and there has been a widespread migration of rural people to urban centres. All these changes are expected to have relevant impacts on the biodiversity, which, in comparison with other European countries, is particularly diverse. For example, there are 95 identified species of mammals in Portugal (Cabral *et al.* 2005), of which 14 belong to the order Carnivora (Santos-Reis & Mathias 1996).

On one hand, with migration to urban areas, urbanization may be transforming attitudes towards nature and carnivores. But on the other hand, there are still many rural areas compared to other European countries, and farmers, hunters and gamekeepers still seem to consider generalistic predators to be extremely harmful, applying non-selective control methods (Delibes *et al.* 2000). Moreover, among the Portuguese rural communities, very often the wolf is still spoken of as a mythical figure, which is promoted by ancient and religious oral traditions that associate the wolf with an anti-Christ figure (Álvares & Primavera 2004).

Changing the negative views of some people regarding carnivores will require a shift in attitudes at a societal level, which will involve educating younger generations through the formal school system (Sillero-Zubiri *et al.* 2004). Teenagers were therefore selected as target group for this study as future decision-makers, and because young people are thought to be most susceptible to social change (Skogen 2003).

A1.1 Aims and objectives

The objectives of this study were to assess Portuguese high school students' knowledge and attitudes towards carnivores, and to examine the effect of certain variables on these, especially the presence/absence of carnivores, the degree of naturalization (urban/rural) of the residence areas, and the relationship between knowledge levels and attitudes. Following are the central questions that this study sought to address:

1. What is the attitude and knowledge level of Portuguese students concerning carnivores?

2. What is the relationship between attitude towards carnivores and knowledge about them?

3. Does the presence of carnivores in the study areas affect the attitudes and knowledge of the target group?

4. Do the attitudes and knowledge of people from urbanized areas differ from those in more rural areas?

5. Does the presence of a large carnivore affect the attitudes of the public towards carnivore conservation?

6. Does knowledge about species which have been subject of greater conservation efforts (e.g. wolf, lynx) differ from other carnivores?

7. How much support is there for conservation, research and education activities?

8. On the basis of the results obtained, which are the best strategies for increasing acceptance of carnivores?

The results of this study should: (1) enable managers to improve education or service to the public, by providing a survey tool that may be applied to other research projects, and produce information that may generate more effective environmental awareness campaigns; (2) help to find out those areas of knowledge which are only weakly understood by the students, and which study areas would benefit from a educational project; (3) allow in targeting educational materials to focus on the concerns and key issues of the various groups. Ultimately, it is hoped that a greater understanding of perceptions towards carnivores and their conservation will help ensure the development of effective conservation programs.

A2. Methods

A2.1. Study species

Portuguese carnivores include 14 species representative of 10 genera and 5 families. Of these, 11 are native in Europe (wolf *Canis lupus*, red fox *Vulpes vulpes*, weasel *Mustela nivalis*, stoat *M. erminea*, polecat *M. putorius*, beech/stone marten *Martes foina*, pine marten *M. martes*, badger *Meles meles*, otter *Lutra lutra*, wildcat *Felis silvestris*, and Iberian lynx *Lynx pardinus*) and 3 are the result of intentional or accidental introductions due to humans (Mathias *et al.* 1998a; Cabral *et al.* 2005).

The genet (*Genetta genetta*) and the Egyptian mongoose (*Herpestes ichneumon*) are two North African carnivores which are assumed to had been introduced in Europe in historical times (≈ 500 years ago), as pets to hunt rabbits and/or rodents (Dobson 1998), and show a limited European range restricted to Portugal, Spain and for the first, also to south-western France (Livet & Roeder 1987). The mongoose is abundant in southern Portugal, specially south of the river Tejo, facing nowadays an expansion period towards the northern area (Borralho *et al.* 1996). The American mink (*Mustela vison*) represents a much more recent introduction ('50s) in different European countries, originating from released or escaping individuals from fur farms (Bonesi & Palazón 2007). This is the case of the Portuguese population, which first report in the wild dates from the late '80s (Vidal-Figueroa & Delibes 1987), being considered a recent introduction in the north-west, due to the accidental escape of individuals from a fur farm located in Valença do Minho, margin of river Minho (Santos-Reis & Mathias 1996).

The brown bear *(Ursus arctos)* occurred historically in Portugal but now it is extinct. Although once abundant all over the country, bears became rare due to the management of the landscape for agriculture and pastures, jointly with excessive hunting, and the last specimen was shot in 1650 (Santos-Reis & Mathias 1996).

Foxes, weasels, beech martens, badgers, otters and genets, occur all over the country in favourable habitats, whilst the remaining species have a more restricted distribution. These species are the most common carnivores in Portugal, and are classified as of ‘‘Least Concern’’ in the Portuguese Red Data Book (Cabral *et al.* 2005).

The Iberian wolf (*Canis lupus signatus*) was formerly abundant all over the country, but nowadays inhabits only the north-eastern and central mountainous

regions (Petrucci-Fonseca 1990). Listed as "Endangered" (Cabral *et al.* 2005), the Portuguese wolf population consists of approximately 300 individuals. The main threats faced by the wolves are the scarcity of wild prey, habitat deterioration due to forest fires and human incursion, and habitat fragmentation due to the proliferation of barriers to movement (Pimenta *et al.* 2005).

The stoat, whose presence in Portugal was only recently confirmed, being only present in the northern area with the southern border of its range not yet clearly defined (Santos-Reis & Mathias 1996), and the polecat, are both considered "Data deficient" in the Portuguese Red Data Book (Cabral *et al.* 2005). Despite having an ubiquitous distribution, the polecat appears to be declining in several regions, supposedly due to the many threats faced by its habitat (Santos-Reis & Mathias 1996), and further studies have been recommended.

The occurrence of the pine marten in Portugal was unknown until the late 1980s. Recent studies confirmed its scarcity and suggested that the species is restricted to northern and interior portions of the country (Matos & Santos-Reis 2006). Moreover, forest replacement by *Eucalyptus* plantations may be causing the pine marten populations to decrease, because they support fewer prey and resting and denning sites (Proulx *et al.* 2004).

The otter represents the single carnivore which conservation status was downgraded in the last revision of the Red Data Book. First considered as potentially threatened (SNPRCN 1990), now was categorized as of "Least Concern" (Cabral *et al.* 2005). A national otter survey, conducted in 1995, showed that the situation is very favourable being presently considered one of the most viable in Europe (Trindade *et al.* 1998); its long term survival may be however threatened by vulnerability of its habitat to man-made changes, aquatic pollution, road kills, and persecution due to competition with fishermen (Cabral *et al.* 2005).

The wildcat is listed as "Vulnerable" as its population is becoming more and more fragmented, being threatened by habitat destruction, persecution, reduced prey availability and cross-breeding with free-ranging domestic cats (Pierpaoli *et al.* 2003).

Lastly, the endemic Iberian lynx is a Critically Endangered species both at the global (IUCN 2006) and national level (Cabral *et al.* 2005). Its strongly selective diet (rabbit based – Delibes & Hiraldo 1981), as well as the destruction of its habitat, the persecution despite of legal protection, and an extremely fragmented distribution

makes it particularly vulnerable to extinction (Bessa-Gomes *et al.* 2002, Pires & Fernandes 2003). In 1997, five main distribution areas in Portugal have been identified in Mediterranean habitats in central and southern regions of the country (Ceia *et al.* 1998); yet posterior local monitoring and research fieldwork have generated little or no evidence of lynx presence (Sarmento *et al.* 2004), being the last known positive sign a scat collected in December 2001 (Santos-Reis 2003).

The fox and the mongoose are game species with a restricted hunting period (Law Decret 202/2004, August 18). The wolf, the lynx, the wildcat and the otter are listed in the Appendix II of the Bern Convention, and the majority of the mustelids, the genet and the mongoose are listed in Appendix III (Cabral *et al.* 2005).

A2.2. Study area

Data collection was conducted in a selected sample of Portuguese districts: Lisbon and Porto (greatly urbanized); Portalegre, Évora and Beja (situated in Alentejo; home for most of the carnivore species and where the Iberian lynx had its last population nuclei in Portugal); Braga, Viana do Castelo, Vila Real e Bragança (situated in the North; territory of wolves, stoats, pine martens and the invasive American mink). The Azores and Madeira archipelagos were not considered for this study since no wild carnivores exist there, with the exception of the weasel in the Azores, believed to have been accidentally introduced (Mathias *et al.* 1998b).

Participating schools were thus located in 4 different study areas (Figure 1.1):

- A: ("Minho e Trás-os-Montes"): North, high density of human populations, presence of carnivores;

- B ("Porto"): North, greatly urbanized, absence of carnivores;

- C ("Alentejo"): South, low density of human populations, presence of carnivores.

- D ("Lisbon"): South, greatly urbanized, absence of carnivores.

Within each of these study areas, an equal number of schools was randomly selected from both urban (designated "1") and rural (designated "2") areas. A school was considered to be located in an urban area if human population was higher than 5000 habitants, in accordance to Portuguese definitions of urban and rural (INE 2002). In the study areas B and D (highly urbanized), specific areas were considered rural if population was considerably lower than in the surrounding areas and general life style was evidently different.

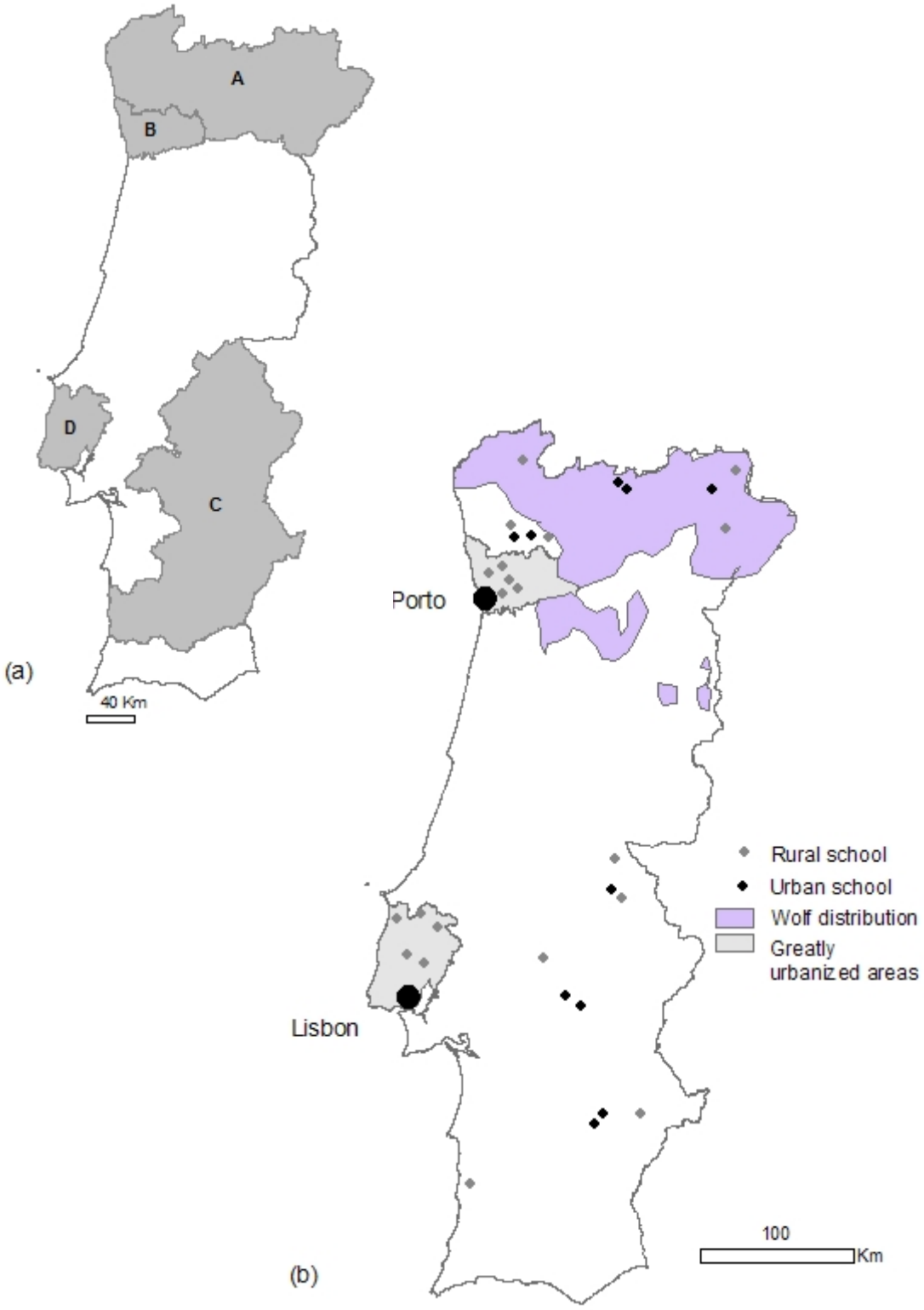

Figure 1.1. (a) Location of the study areas (A, B, C, and D) encompassing the participating high schools. **(b)** Location of the participating high schools (each represented by a dot), and Iberian wolf distribution (drawn from Álvares 2004). Lisbon and Porto dots are larger as they each incorporate 5 urban schools.

A2.3. Questionnaire construction

Students' attitudes were assessed through a quantitative method using questionnaires with fixed, instead of open-ended, questions due to the better codification and quantification methods available (Coolican 2004), and their enhanced reliability (Fink 2006). This self-administered written questionnaire was based on others already used and published (Bath 2000, Bath & Majić 2001, Andersone & Ozolins 2002, Wechselberger *et al.* 2005), but adapted to a Portuguese public. The questions were pilot-tested on a 26-student class which was not included in the final study. After this pre-test, minor amends were made in order to avoid logic and/or question perception errors.

The final questionnaire consisted of 86 questions, mostly about respondents' attitudes and knowledge regarding carnivore species. All attitudinal questions were measured on a 5-point Likert-like scale from 1 (strong negative feelings or attitudes) to 5 (strong positive feelings or attitudes) (Likert 1932). Questions about knowledge were stated as multiple choice questions, offering a "don't know" option to avoid guessing. A number of questions addressed personal and demographic characteristics. An English version of the questionnaire is presented in Appendix 1.1, and the Portuguese in Appendix 1.2.

A2.4. Sampling method

969 students from a sample of 40 high schools were surveyed between December 11th 2006 and January 12th 2007 to assess their attitudes and knowledge regarding mammalian carnivores. The population of interest for the survey was high school students because school attendance in Portugal is obligatory until they enter high school or until they reach the age of 16 years old. Participating students (16.15 ± 1.13 years old in this study; mean ± SD) were thus already taught at least the basic curricular contents about nature conservation. Focusing on students provided an unbiased sample, since respondents were not self-selected: all the students of the participating classes were expected to answer the questionnaire and no student refused to participate in this study.

Sampling was conducted by a simple random cluster method, in which groups are assigned randomly (Fink 2006). All the high schools in the study areas were invited to participate in this study by email and, later, by fax and phone, and their participation depended mainly on reception of request, class availability, and

timetable constraints. To allow rigorous analysis of statistical associations, the 40 participating schools were selected in equal numbers from the different study areas (10 per study area). At each school, one class was indicated by the responsible teachers as available to participate. The questionnaire was individually filled in by the students during a normal class lesson and was supervised by the researcher. Respondents were given as much time as they needed to complete the questionnaire to allow for individual abilities. Time to complete the questionnaire varied between 20 and 40 min.

As an incentive to gain schools' co-operation, after completing the surveys, the students were given a 30-50 minutes presentation entitled “Portuguese mammalian carnivores” in which they were told about species identification, ecological importance of carnivores and their conservation, as well as research methods for their study.

Participation in this study was anonymous, confidential, and voluntary.

A2.5. Data analysis

Due to the considerable number of questions in the survey and the potential collinearity among them, extraction of variables was conducted in order to reduce them to a smaller number of principal components which nevertheless retain a large proportion of the original information (see section A2.5.1.).

After extraction of variables from the questionnaires, the main outcome variables were respondents' attitude score, relationship score, support score, and knowledge score, which association with potential predictors was investigated, namely: presence/absence of carnivores, north/south area, urban/rural area, low/high human population density, presence/absence of previous conflict with carnivores, main source of information about carnivores, sex, residence in village/town/city, frequency of close contact with nature, belonging to organizations related to nature, and wildlife interest score (see section A2.5.2.).

A2.5.1. Extracting variables

Attitudinal questions, concerning students' opinions about carnivores, their conservation, and wildlife in general, as well as knowledge questions, were subjected to extraction of variables. For these 2 types of questions, several scales resulted from scores obtained by multivariate statistical analysis. Summed scales were also

obtained by combining several variables into a single measure (see following sub-sections for details).

A2.5.1.1. Attitudinal questions

Attitudinal questions were split in 3 sections according to content: (1) attitude towards carnivores, (2) support for carnivore conservation, research and education, (3) interest about wildlife. For each section, the same exploratory procedure took place.

Attitudinal questions resulting from the questionnaire (n = 35) were coded on the Likert scale and ordered as categorical variables. Attention was paid to the fact that one cannot assume a priori that the distances between the categories are equal, although this is a common practice in psychological survey studies (Jamieson 2004). Therefore, to examine the component structure of these variables, a CATegorical Principal Component Analysis was used, as implemented in the program CATPCA in SPSS. CATPCA is an optimal scaling method belonging to the nonlinear multivariate analysis techniques. No distributional assumptions about the variables are made and it simultaneously quantifies categorical variables while reducing the dimensionality of the data with minimal loss of information found in the original variables. The variables are transformed by assigning optimal scale values to the categories, resulting in numeric valued transformed variables (Meulman *et al.* 2002).

Due to the small number of cases with missing values (1.1% for support questions; 5.2% for wildlife interest questions; 7.3% for attitude questions) and considerable sample size, cases with missing data on a variable were excluded from this analysis (Hair *et al.* 1998).

For determination of the number of components to be extracted, their interpretability, eigenvalues, and percentage of variance were considered. To interpret the components, the component loadings were examined. The current version of the CATPCA program does not offer rotation options and unrotated solutions can sometimes be difficult to interpret. Therefore, the transformed variables were used as input for a classical PCA with varimax rotation, since the rotated components remain uncorrelated with this type of rotation (Kaiser 1958). In interpreting the component pattern, an item was said to load on a given component if the factor loading was > 0.50 for that component, and was <0.50 for the other (Hair *et al.* 1998).

The saved optimal scores resulting from the CATPCA analyses were used as measures for each set of constructs. Optimal scores do not tell anything about the average intensity of a given construct. They only indicate the position of respondents along a continuum represented by the latent construct, resulting in scores with mean 0 and unit variance (Meulman & Heiser 2004). However, they are especially useful if orthogonality must be maintained (Hair *et al.* 1998).

A2.5.1.1.1. Attitude scale

For the 20 questions concerning attitudes towards carnivores, only the first two components were retained. Combined, components 1 and 2 accounted for 42% of the total variance. Seven items were found to load on the first component, which was subsequently labelled as the attitude score. Six items loaded highest on the second component, which was labelled as the perception of human-carnivore relationship component (Table 1.1.). The items that did not load on any of these two components were eliminated from further analysis.

Table 1.1. Categorical principal components analysis of final statements measuring attitudes towards carnivores – principal component loadings with variable varimax rotation.

Questions	Loadings	
	Component 1	Component 2
Q37. It is unnecessary to have carnivores in Portugal because abundant populations already exist in other countries.	0.624	0.184
Q42. It should be allowed to hunt any carnivore.	0.593	0.124
Q50. Nature conservation is important.	0.576	-0.131
Q39. Carnivores' only function is to kill other animals.	0.574	0.163
Q47. We should preserve carnivores because they have the right to live.	0.559	-0.029
Q36. Carnivores are key-elements in Nature.	0.547	0.265
Q35. Carnivores cause pain to their preys only for pleasure.	0.529	0.236
Q33. I would be afraid of being alone in an area with small/medium carnivores.	-0.135	0.750
Q32. I would be afraid of being alone in an area with large carnivores.	-0.243	0.742
Q38. In areas where carnivores live in close proximity to humans, attacks on humans are common.	0.172	0.596
Q48. Carnivore conservation is important, as long as they do not disturb humans.	0.131	0.577
Q49. Carnivores are a threat to human populations.	0.306	0.568
Q34. Carnivores steal preys from the hunters.	0.169	0.507
Percentage of variation explained	26.6%	15.7%

A2.5.1.1.2. Support scale

Four questions, related to support for carnivore conservation, research and education activities, were strongly correlated and were grouped, forming a support for carnivore conservation variable (Table 1.2.).

Table 1.2. Categorical principal components analysis of statements measuring support for carnivore conservation, research and education activities – component loadings with variable varimax rotation.

Questions	Loadings
	Component 1
Q43. Carnivore conservation is important.	0.742
Q44. More scientific research should be done to preserve carnivores.	0.736
Q46. It is important to spread information on carnivores.	0.763
Q51. I would like to obtain more information on carnivores.	0.703
Percentage of variation explained	54.2%

A2.5.1.1.3. Wildlife interest scale

For the 11 wildlife interest questions, a single component was found with seven items loading on this component. Final items and corresponding factor loadings are presented in table 1.3.

Table 1.3. Categorical principal components analysis of final statements measuring interest about wildlife – principal component loadings with variable varimax rotation.

Questions	Loadings
	Component 1
Q62. I don't like at all/ I dislike/ Neutral/ I like/ I like a lot: bats.	0.815
Q63. I don't like at all/ I dislike/ Neutral/ I like/ I like a lot: shrews.	0.803
Q58. I don't like at all/ I dislike/ Neutral/ I like/ I like a lot: reptiles.	0.795
Q60. I don't like at all/ I dislike/ Neutral/ I like/ I like a lot: amphibians.	0.781
Q55. I don't like at all/ I dislike/ Neutral/ I like/ I like a lot: spiders.	0.751
Q61. I don't like at all/ I dislike/ Neutral/ I like/ I like a lot: rodents.	0.541
Q54. I don't like at all/ I dislike/ Neutral/ I like/ I like a lot: herbivores.	0.509
Percentage of variation explained	51.1%

A2.5.1.2. Knowledge questions

For knowledge questions all answers were coded as dichotomous variables, using 1 for correct answers and 0 for incorrect, do not know and missing answers. Because it is a binary categorical variable, Multiple Correspondence Analysis with ranking discretization was applied using SPSS software. However, all questions had discriminant measures smaller than 0.30 and extracting items did not add clarity to the solution; thus, a single-scale solution was accepted and object scores were obtained, resulting in a knowledge score.

A2.5.1.3. Summed scales

For each of the previously mentioned scales, an alternative summed scale was formed by combining several individual variables into a single composite measure, i.e., combining all the variables loading highly on a factor without taking into account the actual loading weights. Due to the different number of items per scale, the mean score was used as a replacement variable so that the results on different scales were easily comparable.

Summed scales are more appropriate when generalizability or transferability is desired (Hair *et al.* 1998). This is the case, because one of the goals of this study was to investigate the attitude and knowledge levels, to compare score levels with other studies, and to generate results that in the future could be compared to. Moreover, results obtained from a summed scale are easier to understand and give a picture of the mean intensity of each latent construct (Hair *et al.* 1998).

A2.5.1.4. Estimating reliability

Reliability of the scales was estimated with Cronbach's α, and validity is ensured by the fact that most of the questions were taken from previously published reports and studies. Cronbach's α and a simpler version for dichotomous items (Kuder-Richardson measure), were used both when analysing the results from the pilot test and the survey results. Cronbach's α is a commonly used measure of scale reliability using the variance of respondents' scores on each item in relation to overall variance on the scale. Good reliability is represented with α values from around 0.70 up to 1 (Hair *et al.* 1998).

Reliability estimates for all scales were high (attitude: $\alpha = 0.770$, n= 898; relationship: $\alpha = 0.553$, n= 898; support: $\alpha = 0.701$, n=958; wildlife interest:

α =0.840, n=919; knowledge: α = 0.742, n= 969), supporting grouping of related questions. Although the value for the relationship score may be considered too low, this scale was decided to be maintained, since to compare groups reliability coefficients of 0.50 or above are acceptable (Fink 2006).

A2.5.2. Testing hypothesis

After extraction of variables, association of attitude score, relationship score, support score, and knowledge score, with potential predictors was investigated.

As the students are correlated within groups, possibly sharing similar characteristics and views, but independent across groups, linear mixed models (i.e. including both fixed and random effects) were used with 'school' as a random effect to account for the non-independence of observations (Pinheiro & Bates 2000). Applications of mixed models are common in social sciences, specially in research on schools (Fox 2002).

Akaike information criterion (AIC) was used for guiding model selection. The model with the lowest AIC value is considered to be the most parsimonious model, i.e. the best compromise between explaining most of the variation and simultaneously using as few parameters as possible (Crawley 2005). A manual procedure was used for finding the best model.

When applying linear mixed models, analytical assumptions were always examined by graphical inspection of residual plots, namely homoscedasticity, normality of residuals and normality of random effects. All models were fit by maximum likelihood (ML) using the lmer function from the R package lme4 v.0.9975-13.

Due to the current uncertainty and need of further research on how to correctly calculate degrees of freedom when fitting linear mixed models (Baayen *et al.* 2007), the significance of the fixed effects was assessed using the pvals.fnc function from the R package languageR. This function carries out Markov chain Monte Carlo (MCMC) sampling and estimates p-values and confidence intervals on the basis of highest posterior density (HPD) intervals. To assess significance, final models were fitted using restricted maximum likelihood estimation (REML), a modification of maximum likelihood estimation that is more precise for mixed-effects modelling (Baayen *et al.* 2007).

When applicable, significance of fixed factors as a whole (and not only

treatment contrasts) was estimated using the function aovlmer.fnc from the package languageR, in which degrees of freedom are calculated using a anti-conservative procedure being equal to the number of observations minus the number of fixed effects coefficients (Baayen *et al.* 2007).

A2.5.2.1. Comparing between study areas

Summed scales were analysed using linear mixed models in order to compare scores between study areas, in particular to look for the effects of presence/absence of carnivores, low/high human population density, urban/rural situation and north/south area, on knowledge, attitude, perception of relationship, and support. Fixed effects included the categorical variables in study, while school was modelled as a random effect. To avoid multiplicity (problem of getting false-positives due to random variability, Crawley 2005), several predictors were included simultaneously.

To detect differences between study areas on favourite source of information, in which students were allowed to choose more than one answer, each option was coded as a different variable.

A2.5.2.2. Evaluating the influence of factors

To evaluate the influence of several factors on attitude, knowledge, perception of relationship, and support for carnivore conservation, linear mixed models were used. For these analyses, instead of using the summed scales, transformed variables were used to take into account the non-linearity of transformations. School was always modelled as a random effect.

Adequacy of model fit was estimated by comparison of models' residual variance and calculation of a pseudo-R^2.

Analyses were conducted using R v. 2.4.1 (The R Foundation for Statistical Computing 2007) with additional packages, and SPSS v. 15.0.0 (SPSS Inc. 2006). All p-values resulted from use of 2-sided tests and a p-value of less than 0.05 was adopted as the criterion for statistical significance.

A3. Results

A3.1. Comparison between study areas

A3.1.1. Attitude towards carnivores

Students from schools in all the study areas had an attitude score close to 5, which means that the average respondent had a very positive attitude towards carnivores. Students from rural Porto (B2) had the lowest scores, but attitudes did not differ significantly between study areas (F= 0.48, df= 890, p=0.850) (Figure 1.2).

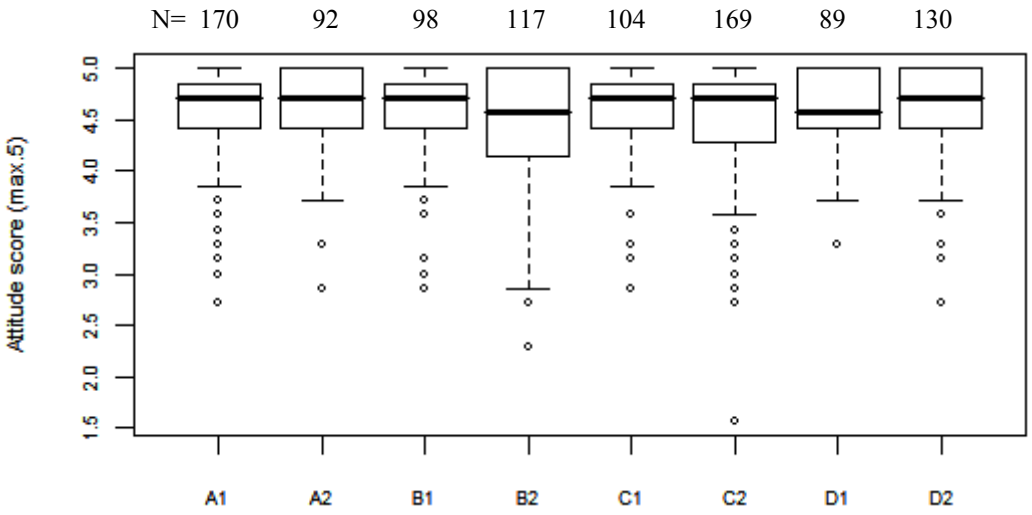

Figure 1.2. Boxplot of attitude score values separated by study area. N refers to total number of students, whilst for all study areas, number of sampled schools is equal to 5.

No significant difference in the attitude towards carnivores was found between students in schools of rural and urban areas, north and south, areas where carnivores were mainly absent or present, or in areas of low or high human population density (Table 1.4). When looking at the effects of two-way interactions between factors that had been designed to be orthogonal (i.e. presence/absence of carnivores, north/south, urban/rural), no significant differences were found.

Table 1.4. Parameter estimates from linear mixed models fitted to students' attitude summed scale (school as random effect). Reported numbers refer to values just before removal of that certain parameter from the model. Best fit model was null with residual variance: 0.23404.

Parameters	Estimate	HPD lower	HPD upper	S.E.	t	Δ Residual variance	p
Southern area	0.044	-0.060	0.160	0.054	0.82	0.00010	0.410
Low population density	-0.070	-0.233	0.091	0.077	-0.91	0.00010	0.391
Presence of carnivores	0.034	-0.124	0.190	0.075	0.46	0.00010	0.673
Urban area	-0.003	-0.119	0.108	0.054	-0.05	0.00001	0.949
Southern x Presence	-0.104	-0.335	0.122	0.107	-0.97	0.00001	0.379
Presence x Urban	-0.105	-0.326	0.130	0.106	-0.99	0.00001	0.354
Southern x Urban	0.086	-0.134	0.330	0.105	0.82	0.00001	0.455

3.1.2. Perception of human-carnivore relationship

Although general attitude was extremely positive, students had a moderate, almost neutral, perception of human-carnivore relationship (Figure 1.3). Students had significant differences in perception according to study area (F= 3.34, df= 890, p= 0.001). The more positive scores were given by students from rural northern areas (A2) and urban Lisbon (D1), and the more negative scores by urban northern students (A1 and B1).

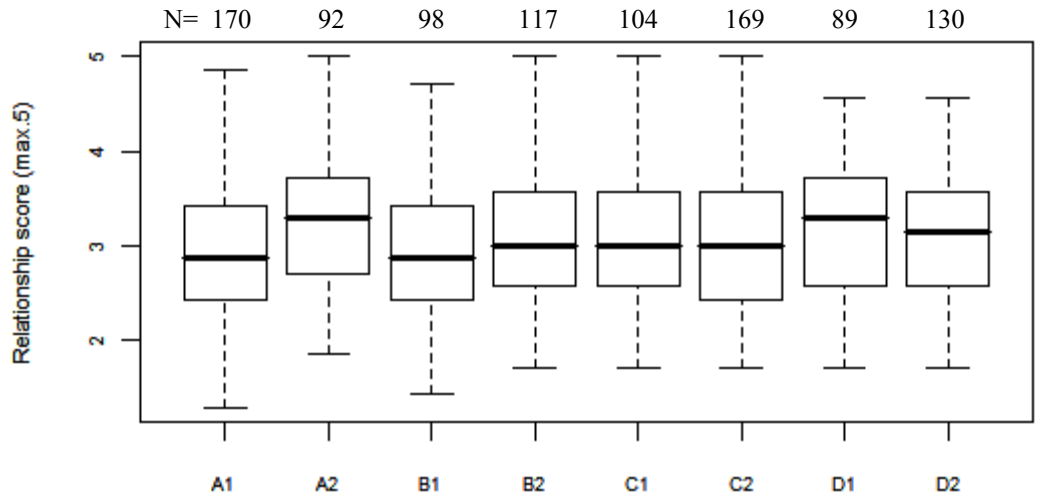

Figure 1.3. Boxplot of perception of human-carnivore relationship score values per study area.

Human population density and presence of carnivores had no significant effect on the perception of the human-carnivore relationship, neither the two-way interaction between presence of carnivores and urban or southern area (Table 1.5). The students were, however, positively affected by the location of their schools in southern urban schools (Table 1.6).

Table 1.5. Parameter estimates of variables removed from linear mixed models fitted to students' perception of relationship summed scale (school as random effect). Reported numbers refer to values just before removal of that certain parameter from the model. Null model residual variance: 0.53003.

Parameters	Estimate	HPD lower	HPD upper	S.E.	t	Δ Residual variance	p
Low population density	-0.056	-0.188	0.079	0.068	-0.82	0.00040	0.393
Presence of carnivores	0.010	-0.128	0.144	0.070	0.15	0.00026	0.881
Southern x Presence	-0.067	-0.265	0.121	0.098	-0.68	0.00027	0.489
Presence x Urban	-0.027	-0.215	0.171	0.099	-0.27	0.00004	0.783

Table 1.6. Parameter estimates for the most parsimonious model for students' perception of relationship summed scale (school as random effect). Null model residual variance: 0.53003.

Parameters	Estimate	HPD lower	HPD upper	S.E.	t	Δ Residual variance	p
Urban area	-0.076	-0.363	-0.088	0.069	-1.38	0.00050	0.002
Southern area	0.067	-0.198	0.054	0.053	1.23	0.00050	0.302
Southern x Urban	0.318	0.121	0.506	0.098	3.23	0.00167	0.002

3.1.3. Knowledge about carnivores

Students had a low median knowledge score, answering less than 50% of the questions correctly (Figure 1.4). Knowledge score did not differ significantly according to study area (F=1.31, df= 961, p=0.240), although students from urban Alentejo (C1) scored in average 5.9% higher (1-2 more correct answers). Percentage of correct answers for each question, per study area, are presented in Appendix 1.3.

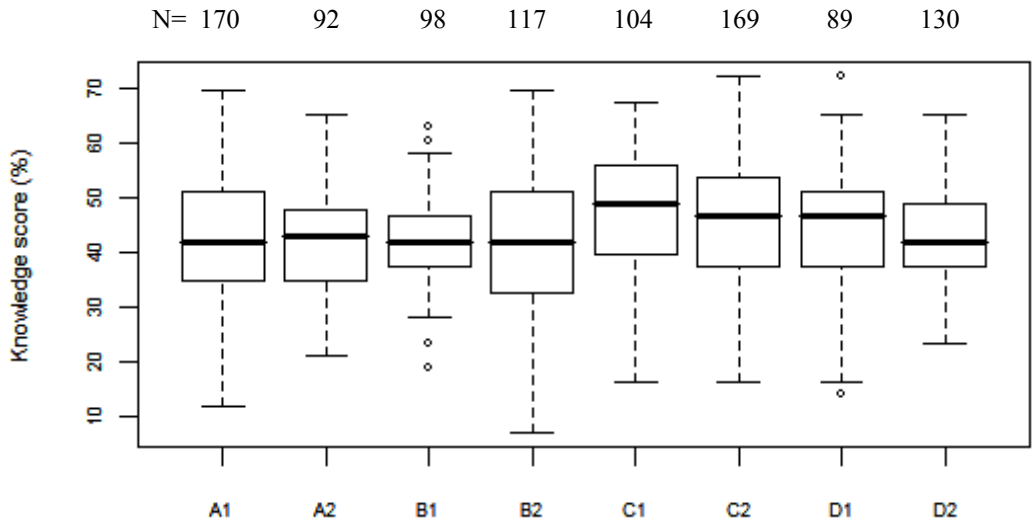

Figure 1.4. Boxplot of knowledge score values separated by study area.

Students from areas of low human population density (i.e. Alentejo) answered correctly, in average, one more question. No significant difference in the knowledge about carnivores was found between students in schools of rural and urban study areas, northern and southern schools, nor areas where carnivores were mainly absent or present (Table 1.7).

Students from schools located in southern study areas had a higher knowledge level about small and medium carnivore species (i.e. carnivores, excluding wolf and lynx) (t= 2.82, p=0.008).

Table 1.7. Parameter estimates from linear mixed models fitted to students' knowledge summed scale (school as random effect). Reported numbers refer to values just before removal of that certain parameter from the model. Null model residual variance: 18.9862.

Parameters	Estimate	HPD lower	HPD upper	S.E.	t	Δ Residual variance	p
Low population density	1.689	0.528	2.892	0.5761	2.93	0.4100	0.007
Southern area	0.599	-0.654	1.893	0.6108	0.98	0.0080	0.346
Urban area	0.182	-0.878	1.198	0.4919	0.37	0.0022	0.739
Presence of carnivores	-0.093	-1.629	1.368	0.6897	-0.13	0.0005	0.886
Southern x Urban	0.793	-1.355	2.812	0.9755	0.81	0.0010	0.449
Presence x Urban	-0.502	-2.695	1.675	0.9726	-0.52	0.0001	0.621
Southern x Presence	1.376	-0.556	3.535	0.9828	1.40	0.0001	0.172

Students from northern areas (closer to wolf distribution areas) did not answered more questions about the wolf correctly (North: 30.5%, 0.86; South: 31.6%, 1.23; mean, SE) (t= 0.96, p= 0.235), neither did students from rural northern areas (t=-0.42, p= 0.675), as they got identical knowledge scores (Rural North: 30.63%, 1.47; others: 31.2%, 0.70; mean, SE).

Rate of correct answers for large carnivores was significantly lower than for other species (school and student ID as random factors: t= 2.85, p=0.008) but this difference was minimal (large carnivores: 42.6%, 0.67; other carnivores: 43.9%, 0.49; mean, SE).

3.1.4. Support for carnivore conservation, research and education activities

Support for carnivore conservation, research and related education activities was generally high, with average respondent stating that he/she strongly agrees with these measures (Figure 1.5). Rural northern students (A2) had non-significantly higher support scores and no significant differences between study areas were found (F= 0.48, df= 950, p=0.840).

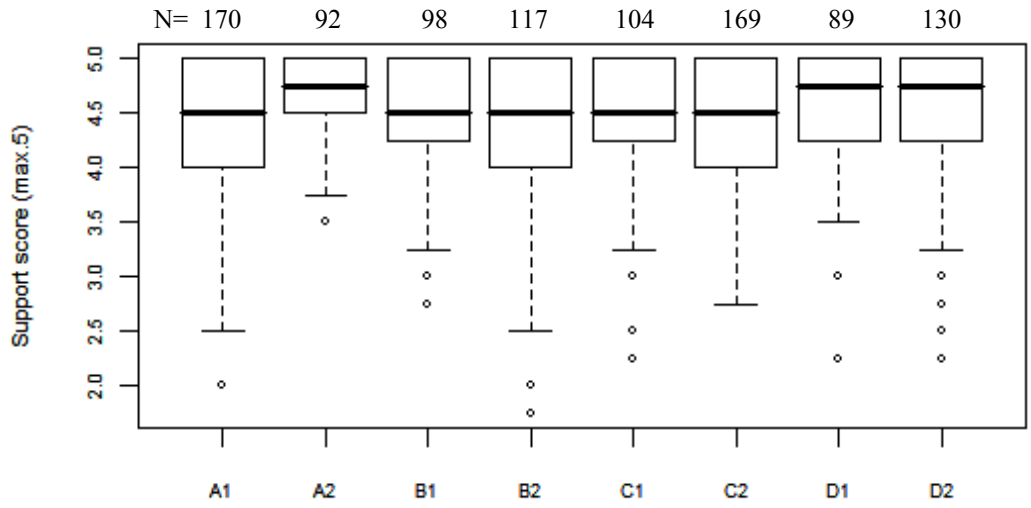

Figure 1.5. Boxplot of support score values separated by study area.

No significant difference in the support level was found between students in rural and urban schools, northern and southern schools , areas where carnivores were mainly absent or present, nor in low or high human population density areas (Table 1.8). Two-way interactions were not significant either.

Table 1.8. Parameter estimates from linear mixed models fitted to students' support summed scale (school as random effect). Reported numbers refer to values just before removal of that certain parameter from the model. Null model residual variance: 0.314962.

Parameters	Estimate	HPD lower	HPD upper	S.E.	t	Δ Residual variance	p
Low population density	-0.05441	-0.2460	0.1459	0.0933	-0.58	0.000058	0.594
Presence of carnivores	0.01772	-0.1760	0.2137	0.0918	0.19	0.000018	0.859
Southern area	0.01995	-0.1783	0.0985	0.0659	0.30	0.000010	0.577
Urban area	-0.04106	-0.1798	0.0884	0.0660	-0.62	0.000010	0.536
Southern x Presence	-0.08251	-0.3562	0.1845	0.1239	-0.67	0.000123	0.588
Southern x Urban	0.17601	-0.0842	0.4515	0.1253	1.40	0.000059	0.198
Presence x Urban	-0.18741	-0.4530	0.0981	0.1280	-1.46	0.000001	0.173

3.1.5. Favourite source of information

Favourite ways of getting information were Internet (24.6%), TV and radio (23.9%), and articles in magazines and newspapers (16.2%). No significant differences in students' preferences were found between urban and rural areas, north and south, nor low and high population density areas for any of the categories.

3.2. Variables influencing attitudes

Students' position in the attitude scale, obtained from the CATPCA object scores, was best predicted by a linear mixed model incorporating knowledge score, wildlife interest, relationship score, human population density (low or high) and whether main information source was folk stories, as fixed factors, and school ID as a random factor. Percentage of students' answers to each attitudinal question by scale category are presented in Appendix 1.4.

Model fit for attitude was rather poor, since these factors only explained 22% of the overall variation (Table 1.9).

Table 1.9. Parameter estimates from the linear mixed model (school as random effect) for the most parsimonious model for attitudes towards carnivores. Residual variance: null model – 0.970; best fit model – 0.756. Pseudo-R^2 = 0.22.

Parameter	Estimate	HPD lower	HPD upper	S.E.	t	Δ Residual variance	p
Intercept	-0.115	-0.405	0.176	0.151	-0.77		0.4494
Human density							
Low	-0.179	-0.343	-0.027	0.086	-2.15	0.079	0.0258
Information source							
Not tales	0.203	-0.089	0.503	0.152	1.34	0.077	0.1816
Relationship score	0.094	0.020	0.168	0.038	2.48	0.071	0.0132
Knowledge score	0.238	0.163	0.313	0.039	6.20	0.041	0.0001
Wildlife interest	0.261	0.186	0.337	0.038	6.84	0.034	0.0001

Although not incorporated in the best fit model, other variables also had meaningful effects on attitude towards carnivores. Boys and students with a closer contact with nature (monthly or weekly) had significantly higher scores, although for students with a daily contact it was only marginally significant higher (Table 1.10).

Students that said that had previous conflict with carnivores showed no significant difference in attitude, and students living in the village, town or city did not differ. Strangely, belonging to organizations related to nature (e.g. scouts) had a marginally significant negative effect on students' position in the attitude scale.

Table 1.10. Parameter estimates from linear mixed models (school as random effect) fitted to students' attitude score with variables not incorporated in the best fit model.

Parameter	Estimate	HPD lower	HPD upper	S.E.	t	Δ Residual variance	p
Contact						0.013	
Monthly	0.343	0.164	0.516	0.090	3.78		0.0002
Weekly	0.379	0.217	0.547	0.084	4.48		0.0001
Daily	0.120	-0.004	0.390	0.101	1.97		0.0558
Residence						0.010	
Town	0.142	-0.031	0.311	0.088	1.61		0.1102
City	0.168	-0.016	0.331	0.090	1.87		0.0624
Sex							
Male	0.145	0.013	0.282	0.068	2.12	0.004	0.0432
Conflict							
Absence	0.154	-0.064	0.370	0.110	1.40	0.004	0.1622
Organizations							
Belonging	-0.180	-0.380	-0.013	0.095	-1.88	0.003	0.0530

3.3. Variables influencing knowledge

Knowledge was best predicted by a linear mixed model fitted with source of information, wildlife interest score, north/south area, sex and frequency of close contact with nature. These factors only explained 7.2% of the overall variation (Table 1.11).

Sources of information with a significant positive effect on knowledge about carnivores were “Movies + Nature films”, “Nature films + Magazines and newspapers”, and “Nature films + Biology lessons at school”. Folk stories, fairy-tales

and legends as main source of information had no significant effect.

Students with a weekly or monthly close contact to nature had significantly higher positions in the knowledge scale. The same cannot be stated for students with a daily contact.

Table 1.11. Parameter estimates from the linear mixed model (school as random effect) for the most parsimonious model for knowledge about carnivores. Residual variance: null model – 0.9024; best fit model – 0.8371. Pseudo-R^2 = 0.07.

Parameter	Estimate	HPD lower	HPD upper	S.E.	t	Δ Residual variance	p
Intercept	-0.373	-0.566	-0.181	0.098	-3.82		0.0001
Wildlife interest	0.274	0.215	0.333	0.030	9.01	0.0953	0.0001
Source of information						0.0638	
Tales+ Movies	-0.498	-1.115	0.129	0.316	-1.57		0.1194
Tales + Docs	-0.340	-0.869	0.160	0.263	-1.29		0.1934
Tales + News	-0.299	-1.974	1.470	0.882	-0.34		0.7200
Tales + School	0.087	-0.391	0.560	0.244	0.36		0.7232
Movies + Docs	0.347	0.115	0.590	0.123	2.83		0.0040
Movies + News	-0.225	-1.127	0.641	0.446	-0.50		0.6230
Movies + Books	-0.452	-1.058	0.199	0.318	-1.42		0.1528
Movies + School	-0.042	-0.394	0.300	0.175	-0.24		0.8088
Docs + News	0.398	0.122	0.670	0.141	2.82		0.0040
Docs + Books	0.174	-0.091	0.441	0.138	1.26		0.2140
Docs + School	0.225	0.071	0.372	0.076	2.97		0.0032
News + Books	0.527	-0.344	1.397	0.445	1.18		0.2406
News + School	-0.034	-0.460	0.349	0.204	-0.17		0.8770
Books + School	-0.238	-0.551	0.080	0.162	-1.47		0.1366
Sex							
Male	0.276	0.152	0.402	0.063	4.35	0.0175	0.0001
North/ South							
South	0.227	0.027	0.418	0.099	2.30	0.0009	0.0272
Contact						0.0003	
Monthly	0.362	0.198	0.517	0.083	4.38		0.0001
Weekly	0.214	0.063	0.369	0.078	2.75		0.0078
Daily	0.015	-0.169	0.197	0.093	0.17		0.8390

Boys had significantly higher positions in the knowledge scale and previous conflict, residence and belonging to organizations had no significant effects (Table 1.12).

Table 1.12. Parameter estimates from linear mixed models (school as random effect) fitted to students' knowledge score with variables not incorporated in the best fit model.

Parameter	Estimate	HPD lower	HPD upper	S.E.	t	Δ Residual variance	p
Organizations							
Belonging	-0.119	-0.292	0.062	0.090	-1.32	0.0009	0.1864
Conflict							
Absence	0.064	-0.137	0.263	0.101	0.63	0.0007	0.5360
Home						0.0002	
Town	0.039	-0.128	0.205	0.085	0.46		0.6296
City	0.088	-0.083	0.267	0.090	0.98		0.3278

3.4. Variables influencing perception of human-carnivore relationship

Best fit model for relationship perception included wildlife interest, sex and whether main information source was folk stories, with females having a significantly lower perception score. This model was poor because it only explained 23% of the overall variation (Table 1.13).

Table 1.13. Parameter estimates from the linear mixed model (school as random effect) for the most parsimonious model for perception of human-carnivore relationship. Residual variance: null model – 0.92; best fit model – 0.71. Pseudo-R^2 = 0.23.

Parameter	Estimate	HPD lower	HPD upper	S.E.	t	Δ Residual variance	p
Intercept	-0.271	-0.557	0.037	0.150	-1.80		0.0696
Information source							
Not tales	-0.002	-0.300	0.283	0.148	-0.01	0.13	0.9798
Sex							
Male	0.455	0.320	0.600	0.071	6.39	0.04	0.0001
Wildlife interest	0.180	0.109	0.249	0.035	5.02	0.02	0.0001

Students that were part of nature organizations had significantly higher position in the relationship scale, as well as students with weekly and daily close contact with nature. Previous conflict, residence and knowledge score had no significant effect on relationship perception (Table 1.14).

Table 1.14. Parameter estimates from linear mixed models (school as random effect) fitted to perception of human-carnivore relationship with variables not incorporated in the best fit model.

Parameter	Estimate	HPD lower	HPD upper	t	S.E.	Δ Residual variance	p
Contact						0.0138	
Monthly	0.085	-0.087	0.262	0.95	0.089		0.3448
Weekly	0.268	0.106	0.431	3.20	0.084		0.0016
Daily	0.329	0.127	0.526	3.25	0.101		0.0008
Organizations							
Belonging	0.265	0.077	0.445	2.82	0.094	0.0058	0.0046
Residence						0.0004	
Town	0.035	-0.140	0.203	0.39	0.088		0.6794
City	-0.071	-0.246	0.119	-0.76	0.093		0.4328
Knowledge score	0.036	-0.029	0.104	1.06	0.034	0.0003	0.2918
Conflict							
Absence	-0.129	-0.338	0.089	-1.19	0.108	0.0002	0.2346

3.5. Relationship between attitude and support for carnivore conservation, research and education activities

Attitude scores proved to be an important predictor of support, since they were positively correlated (t=24.31, p=0.0001), explaining 36% of the variation in support. The perception of relationship was also positively correlated with support (t=6.78, p=0.0001), and explained 17% of the variation. Knowledge, although also positively correlated (t=3.66, p=0.0003), only explained 7.5% of the variation.

A4. Discussion

Portuguese high school students had very positive attitudes towards carnivores and their conservation, but a general feeling of fear was found among them. Knowledge about carnivore species was generally low. The only significant difference between study areas was a more positive perception of human-carnivore relationship found for rural areas, and specially for southern urban areas. Summary of results from tests on variables affecting attitudes, relationship perception, knowledge and support for carnivore conservation are presented in figure 1.6.

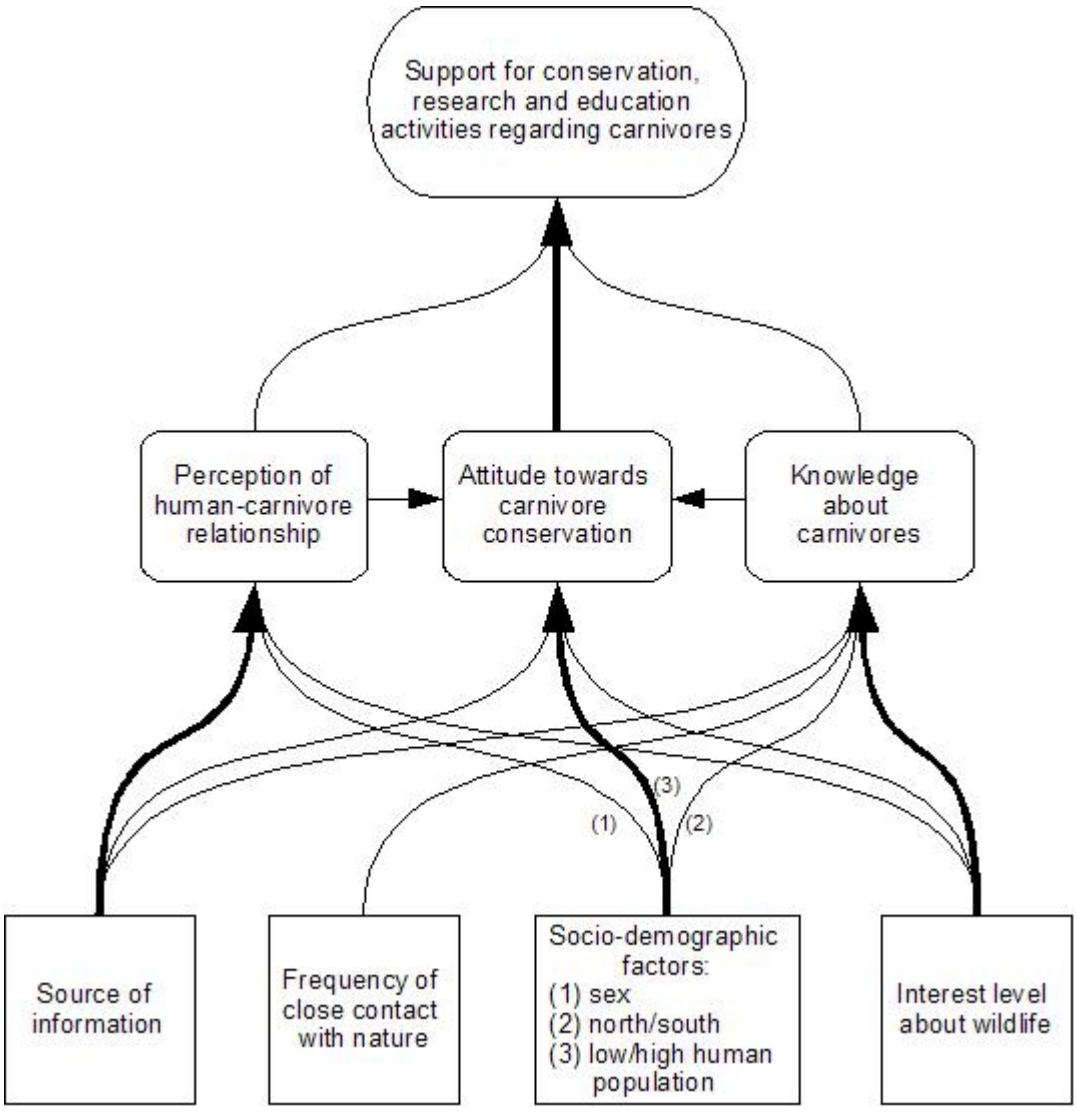

Figure 1.6. Summary of results from best fit models obtained by testing of the relationship of different variables on the attitude towards carnivore conservation and thus the support for carnivore conservation, research and education activities regarding carnivores. Thicker arrows illustrate the variable which explains most of the variation for a certain response.

A4.1. *"Carnivores are cool!"*

Very positive attitudes towards carnivores were recorded across all study areas. These are similar to results from North America and other parts of Europe, which often indicate a strong positive feeling from students or a polarized viewpoint (strong liking and strong disliking with few neutral) toward wolves (Williams *et al.* 2002). Espirito-Santo and Petrucci-Fonseca (2004) had already reported Portuguese students to have among the most positive attitudes towards wolves when compared with other interest groups.

Several studies have reported that distance to the nearest wolf territory had a significant effect on human attitudes, and that the further from a wolf territory the respondents lived, the more positive they were towards wolf conservation (Williams *et al*. 2002, Karlsson 2007). Yet, proximity to wolf territory did not have a significant effect on students' attitudes and, contrary to what was expected, differences in proximity to carnivore distribution areas and rural environment are not main predictors of Portuguese students' attitudes towards carnivores.

The similarity of attitudes might be explained by the mobility of students, which may dissolve the social characteristics of a region, especially because students from more rural areas attend schools located in bigger cities, most likely affecting their views about nature and rural life. In contrast to this study, other studies have generally found that rural inhabitants have more negative attitudes towards carnivores than other socio-demographic groups (Roskaft *et al.* 2003), but similarity of attitudes towards large carnivores among urban and rural citizens has also been reported for Sweden (Roskaft *et al.* 2003) and Latvia (Anderson & Ozolins 2004). Students from London were even significantly less positive towards wolves, bears and otters than teenagers from rest of England (Bath & Farmer 2000), and rural Spanish students had more positive attitudes than urban students (Bath & Farmer 2000). This seems to indicate that the division between urban and rural areas can be misleading when considering attitudes towards carnivores. Lack of clear criteria to distinguish between urban and rural areas between studies may be uncovering a common trend.

The favourable attitudes may also be explained by generally low damage levels caused by carnivores. Although 10.6% of the students said they had previous conflict with carnivores, this factor had no significant effect on attitudes. This is quite contrary to findings from Norway, where a high conflict resulted in a largely

negative attitude (Szinovatz 1997). However, damage levels resulting from human-carnivore conflict are likely to be considerably different between Norway and Portugal, and probably conflict events were not taken as important threats, not affecting significantly their attitudes. Furthermore, conflicts tend to occur in areas where large predators, primarily wolves, have reappeared after a long period of absence or where they have been introduced with human assistance (Williams *et al.* 2002). And, so far, no reintroduction of carnivores has taken place in Portugal.

Throughout history, human values towards large carnivores have been inversely proportional to their abundance (Schwartz *et al.* 2003). Since the brown bear is long extinct in Portugal, the Iberian lynx is virtually extinct, and only around 300 wolves still remain, positive attitudes indicated by this study may be also explained by large carnivores low abundance.

Lastly, very positive attitudes might be explained by people's fascination by danger and frequent presence of carnivores in our culture, namely in literature, in children's stories, in art, etc. (Kruuk 2002). It is possible that young people, such as high school students, feel especially attracted by this kind of species.

While several studies have shown that respondents with higher knowledge levels about wolves tend to have more positive attitudes toward the species (Kellert 1985, Bath 1989, Bath & Buchanan 1989), an increase in knowledge can also affect attitudes in a negative direction (Bath 1994). In this study, knowledge levels correlated with attitudes, with greater knowledge contributing to more positive attitudes. Yet, it should be taken in consideration that education aimed at fostering more positive attitudes toward predators by increasing factual knowledge has proved to be ineffective in some conservation projects, sometimes even reinforcing negative attitudes among those who already have strong views (Kellert *et al.* 1996).

Several studies showed that other factors also have an important effect in attitudes, meaning that it would be difficult or even impossible to improve attitudes just by increasing knowledge. For example, basing themselves on folklore stories and legends, people picture carnivores as dangerous animals, and being definitely damaging (Kruuk 2002). Moreover, fearful people generally show the most negative attitudes toward carnivores (Wechselberger *et al.* 2005). In agreement with this, attitudes were best predicted by a model incorporating positive effects of knowledge score, wildlife interest, perception of relationship score, absence of folk stories as main information source, and a negative effect of low human population density.

In agreement with DeRosa (1984), according to whom gender has a major effect on how children perceive the world, male students had a more positive attitude than female students. The more positive attitudes expressed by the male respondents could be explained by the fact that boys are generally more familiar with wild animals, probably due to a greater affinity with these animals but also due to a different role played in human society, specially in rural and more traditional areas. However, gender was not a main predictor of attitude, maybe because although boys are generally more familiar and have a more positive attitude, girls generally score higher in questions involving moral reasoning (DeRosa 1984).

Contact with nature also had a significant positive effect on attitudes. This was more important when contact was weekly or monthly, rather than daily. This may indicate that people that frequently contact with nature as entertainment or tourism may enjoy and appreciate it more, while students that actually live in such an area, may see it as a restriction and contact more often with conflict situations, thus worsening their attitudes. Even so, daily contact was positively correlated with positive attitudes, and these students' attitudes differ significantly from those who reported to contact with nature less than once a month, which is in support of Zimmerman *et al.* (2001), according to whom aspects of negative attitudes towards carnivores will be reduced with exposure to them. Alternatively it could simply be the case that people that are already interested in wild animals practice outdoor activities more often than others.

A4.2. *"Who's afraid of the big bad wolf?"*

General perception of the human-carnivore relationship was moderate, almost neutral. The main predictors of the relationship score were wildlife interest, whether main information source was folk stories, and gender, with females having a significantly lower score. This seems to be in accordance with Kruuk's (2002) opinion that the strong emotions that typify human perceptions of carnivores have an innate basis. Folk stories' role in shaping attitudes may be especially relevant when considering the fear component, because they often show carnivores as tricky and dangerous animals (Piñero 2002).

In Portugal, there are no reports of attacks on humans by healthy (non-rabid) wolves (Petrucci-Fonseca 1990). However, only 12% of the students answered correctly that there was not any attack on humans by wolves in Portugal in the last 50

years, while 35% of the students believed the number of attacks to be around 5 to 30. This may partly explain the low relationship score, since a considerable part of the students believe the attacks by wolves are relatively common. Students self-reported fear not only towards large carnivores but also towards other species, since 33% of the students said they strongly agree or agree that "in areas where carnivores live in close proximity to humans, attacks on humans are common", and 19% that "carnivores are a threat to human populations".

Fear of animals may often appear to be irrational under present circumstances, yet it has had adaptive value in our evolutionary past (Roskaft *et al.* 2003). Behavioural adaptations to protect against the threat of predation by carnivores and behavioural response to carnivores as competitors, responding with straight aggression, may have profound implications for our understanding of public reactions to carnivores (Kruuk 2002). Nearly one in four students in Northern Ireland, where wolves have been absent for more than 200 years, believed attacks on humans by wolves were common (Bath & Farmer 2000). Fear of bears is an important factor for people's attitude in Slovenia (Kaczensky *et al.* 2004), and the same was found for wolves in North America and Japan (Bath 1991, Kanzaki *et al.* 1996). Most of respondents to Anderson and Ozolins' (2004) survey also showed fear for large carnivores, especially women, while Tucker and Pletscher (1989) and Lohr *et al.* (1996) reported that positive attitudes to wolves was associated with less fear for human safety. Thus, the results from this study are in accordance with human general feeling of fear towards carnivores.

While fear exists among Spanish students, it is least prevalent in areas where wolves occur (Bath & Farmer 2000). Similar research in Croatia showed the same response amongst adults with 41 per cent of the general public living in wolf areas indicating fear, in contrast to the 53 per cent in areas where there are few or no wolves (Bath & Majić 2001). Studies from many parts of the world show that wolf presence affects the activity of humans (Kanzaki *et al*. 1996, Bath & Majić 2001). The only significant differences in perception of relationship by Portuguese students were found between rural and urban students, with urban students having worse scores, and for southern urban situation, areas in which students had more positive perception. This may be due to general low levels of conflict, and absence of reported attacks of carnivores on humans. Animal phobia is greater when people have lost contact with the animals in question (Diamond 1993). Though no

significant effect was found for presence of carnivores, rural students' slightly more positive perceptions of human-carnivore relationship support the hypothesis that contact with nature and outdoor activities may decrease fear of carnivores. Likewise, southern urban students could be affected by proximity to carnivore distribution areas, since they a greater contact with these species occurs in southern Portugal.

Females have shown to be more afraid of carnivores than male students. It has been suggested that differences in fear of wild animals between men and women may be explained by different sex-roles in our evolutionary past, women being more attached to the vicinity of the camps while men were hunters, and the fact that the consequences of an attack on women are more likely to be fatal (Roskaft *et al.* 2003).

A4.3. *"We like them but we don't know what they are"*

Although 73% of the students said they like or strongly like carnivores, the findings of this study indicate that Portuguese students have a low knowledge about them. Low knowledge levels have been reported by most studies regarding attitudes towards carnivores (e.g. Bath & Farmer 2000, Kaczensky *et al.* 2004), namely knowledge about wolves in Portugal (Espirito-Santo & Petrucci-Fonseca 2004). General low knowledge about carnivores is probably related to the species' mainly nocturnal behaviour, specially in areas where they coexist with humans.

For the stoat, genet, mongoose, pine marten, polecat and American mink, most students are unaware of their existence in Portugal. For the mongoose, this only occurred in northern areas, being commonly known in the south, where it is know to occur; likewise, this may be understandable for the stoat and pine marten, whose occurrence in Portugal has only recently been described, and for the American mink, a newly introduced species in this country (see section A2.1. for details on species). However, it may be especially relevant for the genet and polecat, species with a ubiquitous distribution in Portugal.

The rate of students that answered correctly the question about genet's distribution area in Portugal was extremely low for all study areas. Moreover, only 23% of the students said the genet occurred in Portugal, and 65% said they did not know this species. A similar situation occurred for the polecat, as 61% of the students said they didn't know the species, and only 26% said the polecat occurred in Portugal. The considerable amount of students that ignore the existence of the genet,

one of the most common carnivores in Portugal, while the majority of the students recognize the existence of the wildcat, an endangered and fair less common species, may be due to the fact that many people mistake these two species, naming both as "gato bravo" (wildcat).

Only 3% of the students answered correctly about the wolf prey capture success. While biological research in Portugal has yet to determine the success rate for wolves with respect to the number of chases of wild prey, research from North America suggests that success rates per chase tend to be quite low (Mech *et al.* 2001). A widely held belief that the species is an incredibly efficient killer (50% or better success rate) could be directly influencing attitudes toward their perceived impact on other animals.

Contrary to what was expected, rural northern students did not answer correctly more questions about the wolf, and southern students answered more questions correctly, but this difference was minor. Similar results have been reported for areas with low and high American black bear density, where lack of knowledge of bear biology was found in both (Bowman *et al.* 2001). This may suggest that higher carnivore densities will not necessarily lead to an increase in carnivore knowledge.

Identical knowledge rates about large carnivores (Iberian lynx and Iberian wolf) and the other Portuguese carnivores may indicate that education programmes, which have been focusing mainly on those two species, may be failing in educating about basic biological aspects, highlighting the need for education programmes than do more than simply provide facts and information. Although generally recognized by most of the students, respondents failed to answer correctly half of the questions, specially the questions regarding wolves' feeding ecology and attacks on humans. However, students showed a higher knowledge about the lynx, what may be relevant for the success of a reintroduction programme of the Iberian lynx in Portugal, which is nowadays being considered by wildlife managers. Yet of particular importance will be to assess the attitudes of those most likely to be affected by the reintroduction programme.

Differences on knowledge about wolf and lynx could also be related to different temporal effort in education campaigns. Campaigns at schools about wolf conservation in Portugal were specially common in the late 90s, while nowadays they focus mainly the lynx, despite wolf conservation still being a essential topic to

approach. It seems thus that educational efforts on wolf conservation should be continued and implemented in curricular education, rather than limited to a certain time when an event or media focused on it.

It should be taken in mind that it is very difficult to quantify knowledge, and increased knowledge may not necessarily cause a change in attitude, although it may be a basis to reinforce and rationalize attitudes (Kellert 1994, Kellert *et al.* 1996).

A4.4. *"Study them, save them and teach us"*

Even though students showed poor knowledge levels towards carnivores, support for their conservation and research, and interest in education activities was clearly high. Students with a negative attitude had a neutral support position, what points to the importance of reaching to this target. However, it also indicates difficulty to reach this group with public information efforts since they showed little interest in obtaining more information.

Believing that educational campaigns occurred mainly in the classroom context, it is possible that the person responsible for passing the message to the students also affected significantly the results, especially because Portuguese Biology teachers may have a education background focused on either Biology or Geology. Therefore, specially when approaching students with less interest and innate more negative attitude, it is possible that teachers with different personal interest in the topic would also affect the students' perceptions.

A4.5. Recommendations and future directions of research

Successful carnivore conservation strategies depend on the public involvement and only an informed public will be able to show a commitment to conservation. Support for carnivore conservation was correlated with students' attitudes and knowledge; it seems thus that educational campaigns in schools would be useful, to reinforce the general positive attitudes, and mainly to increase knowledge levels, and decrease self-reported fear of carnivores.

Causal relationships between attitudes, knowledge, and behaviour are certainly not clear (Hungerford & Volk 1990). Despite the correlation between attitudes and knowledge found in Portuguese students, it would seem appropriate to target negative attitudes rather than simply providing more information. Only 1.5% of students hold negative attitudes (attitude score 1-2) towards carnivores, whilst

8.9% of the students had a neutral position. Conservation problems may well be caused by just a few people, so it should be paid attention to the fact that people with positive attitudes may actually not do anything to preserve carnivores, while the others may be very efficient in trapping and killing them.

Álvares *et al.* (2000) assessed children and adult's attitudes towards the wolf in two rural areas in Gerês National Park (near to study area A). Their results showed the need for an information campaign among children, but also that those inhabiting areas where wolf attacks are less frequent have a more open attitude towards new concepts and are more prone to changing their opinions, given the right information. Thus, it should be taken in mind that although attitudes and knowledge levels were similar across study areas, it is possible that students from certain areas are more reluctant to change their opinions.

Experience from other places in Europe has shown that it is difficult to reach local people holding a negative attitude towards carnivores with written material only (Bath & Majić 2001, Kaczensky 2003). A website with information and interesting links would help to reach students, because Internet was the most chosen source of information, and also due to its cheaper maintenance and wider range. Regular personal contacts are required, and the participation of a researcher in the classroom, similarly to what was done for this study, could be more efficient than just distributing educational material. Documentaries, together with newspapers and lectures, were the information sources with more positive effect on students' knowledge, and future campaigns should rely on these ways of communication.

This study detected several topics which could be useful when targeting an environmental campaign for protection of carnivores. For example, in terms of developing a persuasive communication message, maintaining carnivores for future generations seems a strong message, because 88% of the students agreed with this statement. Likewise, a recent report from WWF-UK (2000) suggests that tourism and carnivores can generate significant economic benefits to local communities, and interestingly, 61% of the students agreed that “The presence of carnivores may favour tourism”. Students notion about carnivores' non-consumptive economic importance may be of vital importance for their conservation. For instance, value for ecotourism was the most common reason given by ranchers from southern Africa for protecting wild carnivores (Lindsey *et al.* 2005).

Although conflict was not a main predictor of attitudes, carnivores are still

seen as a threat by many students. Considering that the relationship score was one of the main attitude predictors, it seems of fundamental importance to inform about the actual levels of attacks. Quite often, however, such information is received with great scepticism (Roskaft *et al.* 2003). The emphasis should both be on providing education and on getting people out into carnivore habitat to acquire benign or positive experiences. A successful example of an educational program in Norway could be used as example (Gangas 2004). Aiming to increase knowledge about large carnivores in an area where wolves were reintroduced, researchers invited the local population to accompany them in fieldwork tasks, visited schools, and distributed updated research news to every household. This program has been taking place for some years and results have been extremely positive, pointing to an increment in curiosity and interest about carnivores, and decrement in fear.

Whereas students' attitudes toward carnivores may be overall positive, it is fundamental to assess other interest groups. Thus, the questionnaire that I produced for this project is currently being used by another researcher from Faculty of Sciences, University of Lisbon. This identical survey instrument, with some more questions concerning more detailed and management related aspects, is being administered both to Portuguese hunters and people working in environmental related jobs. It will be fundamental to obtain a better picture of the Portuguese citizens' attitudes towards carnivores, by comparing these results with the data that is being currently collected, in order to develop public information that focus on the concerns, misbelieves and key issues of the various interest groups.

Also required in Portugal is a quantification of damage levels caused by carnivores and removal numbers of carnivores by farmers, hunters and other target groups, because indiscriminate removal of predators due to their perceived contribution to stock loss is a common characteristic of carnivore management (e.g. red fox on farmlands in the United Kingdom (Baker & Macdonald 2000)).

Lastly, acceptance of carnivores depends on animal characteristics (Kleiven *et al*. 2004), but also on people's demographic and personal variables, which implies that sociologists, teachers, and other professionals should be involved in future conservation actions.

CHAPTER B

"Feeding habits of the jaguar: local and regional perspectives"

B1. Introduction

The feeding ecology of large predators, such as the jaguar, is essential for understanding the role that carnivores play in shaping the structure and function of ecosystems (Terborgh et al. 1999). Knowledge of their diet is not only important for evaluating the relationship between carnivores and their environment, but diet composition is also relevant to the animal-human interaction, providing part of the ecological background for our behaviour in relation to carnivores (Kruuk 2002).

The jaguar *Panthera onca (*Linnaeus, 1758) is the largest extant Neotropical felid, and it is considered Near Threatened with a declining population trend due to degradation of its habitat and prey base, and to direct persecution, as a result of attacks on the livestock (IUCN 2006). Jaguars have been eliminated from approximately 54% of their 1900 range (Sanderson *et al.* 2002), a decrease noticeably more drastic within the last 50 years, now ranging through Central America to eastern Colombia, Venezuela, Suriname, the Guianas, Brazil, and south into Peru, Bolivia, the Paraguayan Chaco, and northern Argentina (Figure 2.1., Sunquist & Sunquist 2002).

Figure 2.1. Distribution map of the jaguar (Sunquist & Sunquist 2002).

Traditionally, the jaguar has been considered a opportunistic species in its feeding habits (Seymour 1989), with more than 85 prey species described, ranging from turtle eggs to deer and cattle (Sunquist & Sunquist 2002). However, some recent work suggests that it may discriminate between larger prey, exhibiting positive selective tendencies towards collared peccaries *Tayassu tajacu* (Weckel *et al*. 2006a). Other work shows that the diet can be based on other food resources such as medium-sized mammals, particularly armadillos and coatis (Novack *et al.* 2000). Jaguars have also been reported to kill livestock throughout South and Central America, mainly in deforestation frontiers (Michalski *et al.* 2006).

One of the factors that has been used to explain trophic variability is latitude, with a general prediction that relates high latitudes to high diet diversity (Pianka 1966, Gompper & Gittleman 1991). Use of larger prey has also been suggested as distance increases from equator (González & Miller 2002), and others have suggested that use of medium-sized prey by jaguars may be associated with human disturbance (Novack *et al.* 2005). In a review of puma (*Puma concolor*) food habits, Iriarte *et al.* (1990) reported that pumas take fewer large prey in less open habitats (e.g. rainforest).

It has also been suggested that highly selective foraging decisions characteristic of jaguars of more open habitat may be limited by low visibility and fewer predictable sites for prey aggregation in tropical rainforests (Scognamillo *et al.* 2003), where jaguar diet would largely reflect chance encounters.

Study areas of published works describing jaguar diet range from, for example, the Brazilian Atlantic rainforest (Garla *et al.* 2001) to Mexican deciduous dry forest (Núñez *et al.* 2000) and Paraguayan semi-arid lowland (Taber *et al.* 1997). Only one study has addressed jaguar diet in the Amazon Basin (Manu National Park, Peru; Emmons 1987), despite the importance of this area for the long-term survival of this species (Sanderson *et al.* 2002). Similarly, only a few studies have analysed simultaneously the diet composition of jaguar and abundance of its prey (Scognamillo *et al.* 2003, Novack *et al.* 2005, Weckel *et al.* 2006a).

In this study, the diet of the jaguar in Cantão State Park, situated in the Brazilian Amazon Basin, and its prey selectivity are documented.

The jaguar and the puma are sympatric throughout the jaguar's distribution in the Neotropics. These sympatric big cats may avoid direct competition by hunting in a specific manner and often differing biotopes, avoiding predation at the same time

in a particular habitat, and preferring slightly different prey spectra (Scognamillo *et al.* 2003). Diet composition and prey selectivity in two study areas (Cantão State Park and Emas National Park) where attacks on livestock by big felids (pumas and jaguars) are known to occur, were compared in order to investigate the importance of livestock on their diet.

Also described is the pattern of the food spectrum of jaguars at the biogeographical scale by reviewing the available literature. In addition, I tried to relate the diet characteristics to several predictors based on suggestions of previous studies on the food ecology of the jaguar and other large predators.

B1.1 Aims and objectives

To provide a better insight into the feeding habitats of *Panthera onca*, this study focused on four key topics:

1. To describe the diet of jaguars at a local scale, using Cantão State Park as the study area.

2. To investigate prey selectivity by jaguars in the study area.

3. To investigate importance of livestock on the diet of big cats in two study areas: Cantão State Park and Emas National Park.

4. To analyse the biogeographical patterns in the feeding habits and trophic diversity of prey of the jaguar.

B2. Methods

B2.1. Assessing diet of jaguars and big cats

B2.1.1 Study areas

Cantão State Park (09°30'S, 50°05'W), a 89,000 ha protected area in northern Brazil (Figure 2.2), lies in the border between the Amazon rainforest and the cerrado ("Brazilian savannah"). Emas National Park (18º19'S, 52º45'W) is situated in central Brazil and is one of the largest and most important reserves in the cerrado region.

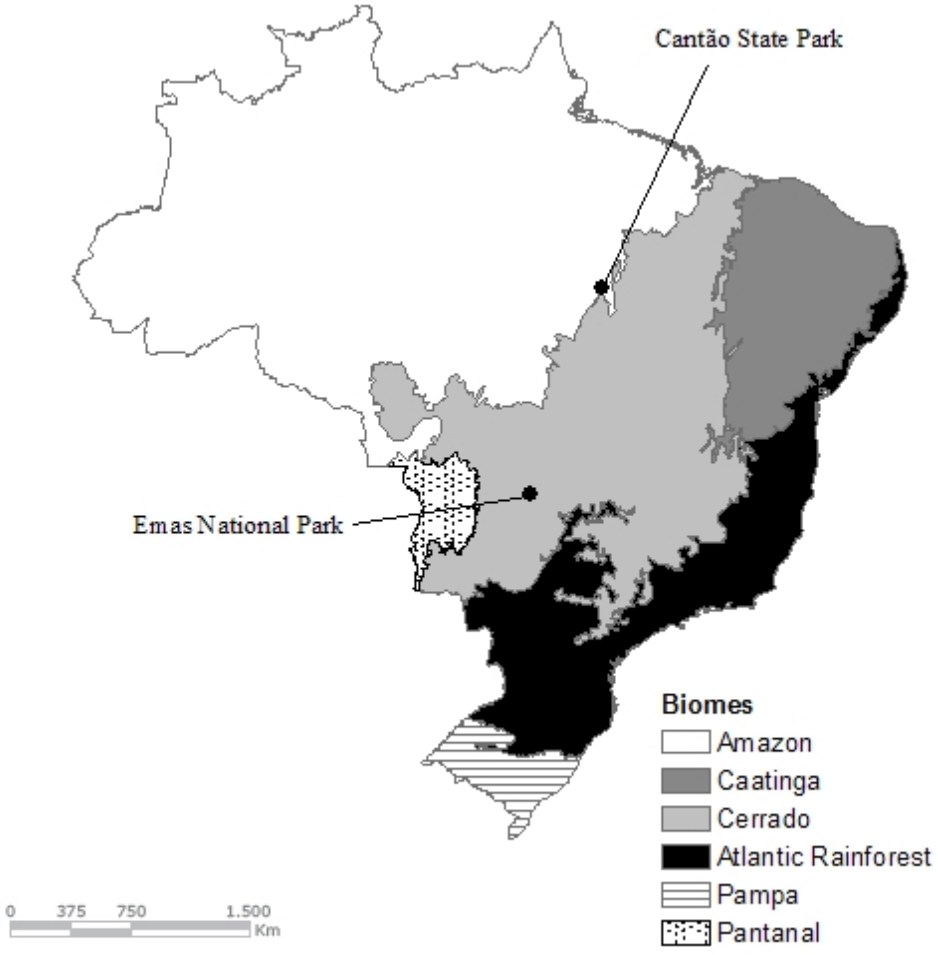

Figure 2.2. Location of both study areas in the country and within main biomes found in Brazil.

In Cantão, mean annual rainfall is around 1900 mm and mean annual temperature is 26°C. A cyclic dramatic change in water abundance occurs between wet season and a prolonged dry season with little rainfall and high temperatures, extending from May through October (Vitt *et al.* 2007). With a vast water network of more than 800 lakes, interconnected during the rainy season, the predominant vegetation away from the rivers is typical for cerrado. In more humid areas, it is characterized by seasonally flooded areas occupied mainly by grasses ("varjões"), or typical tropical forest. This park has been threatened by fires, fishing, tourism, and encroachment by intensive farming (SPMA 2000). To increase the probability of sampling several different jaguars, the surrounding 47,000 ha of the Santa Fé Ranch were also included (Figure 2.3). Around 50% of the ranch is protected, with no hunting and fishing allowed, while the remaining area is occupied by pastures, cattle and small houses.

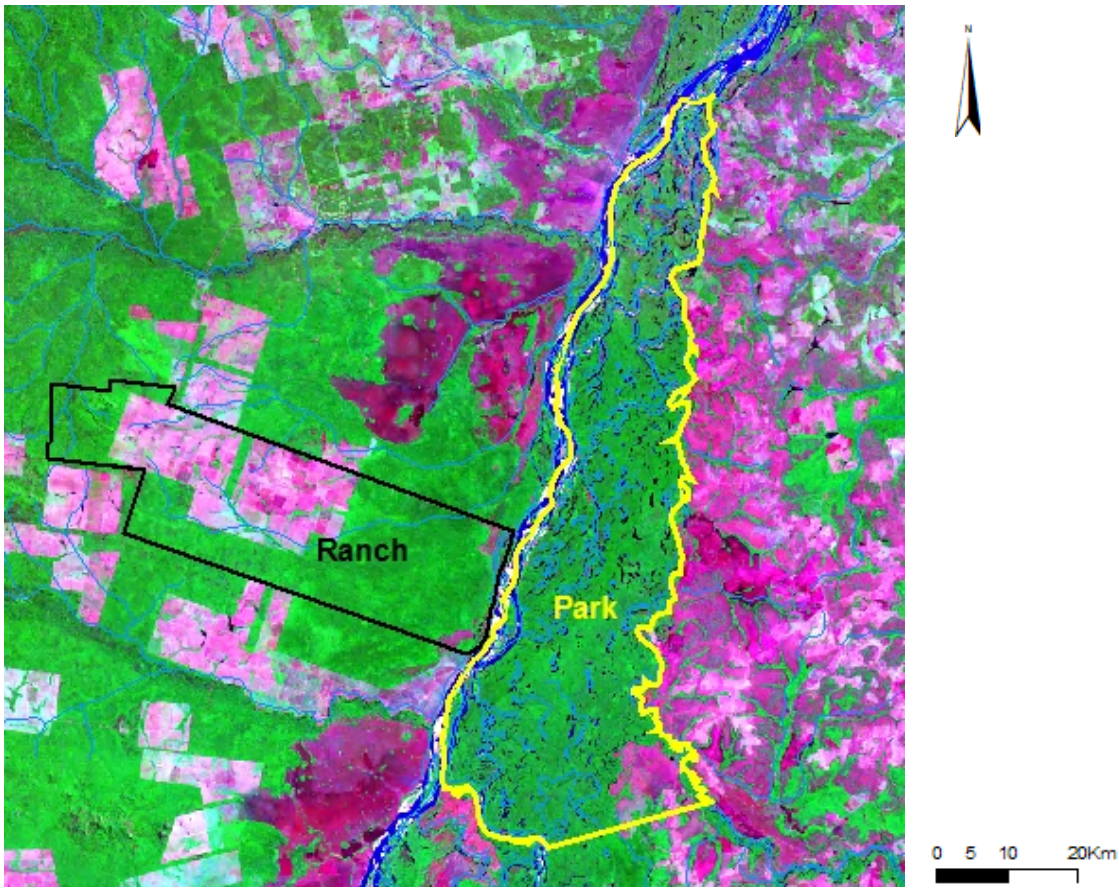

Figure 2.3. Map of land use type and location of Cantão State Park and Santa Fé Ranch. Deforested areas and ranches are illustrated in pink.

In Emas, regional climate is humid tropical with wet summer and dry winter. Annual rainfall varies from 1200 mm to 2000 mm, concentrated from October to March, and mean annual temperature lies around 24.6°C (Ramos-Neto & Pivello 2000). There is almost no rain the rest of the year, when temperatures reach 39◦C and may drop as low as −1.5◦C. Its 132 000 ha protects large grassland plains (97%), patches of shrub fields (1%), marshes, and riparian forest (2%). Emas is located in one of the most productive agricultural areas of Brazil, where soybean and cornfields are the main cause of the fragmentation of the landscape (Jácomo *et al.* 2004).

Jaguar and puma are the largest carnivores residing within both study areas. Smaller mammalian carnivores include, for example, crab-eating fox *Cerdocyon thous,* maned wolf *Chrysocyon brachyurus,* ocelot *Leopardus pardalis,* and tayra *Eira barbara.* Potential large-bodied prey (>10 kg) are represented mainly by ungulates, including tapir *Tapirus terrestris,* collared and white-lipped peccary (*Pecari tajacu* and *Tayassu pecari*), pampas deer *Ozotoceros bezoarticus,* marsh deer *Blastocerus dichotomus,* brown brocket deer *Mazama gouazoupira,* and red brocket deer *Mazama americana*. A variety of medium-sized (2–10 kg) and small (<2 kg) prey also are available.

In Cantão, estimated densities of big cats are 5.3 jaguars/100km^2 and 1.7 pumas/100 km^2 (Negrões, N. personal communication), and, though there is no estimation of home range for this study area, the smallest conservatively estimated home range size for jaguar is 10 km^2 for a female in a tropical forest habitat (Rabinowitz & Nottingham 1986). In Emas, estimated densities are 2 jaguars/100km^2 and 6 pumas/100km^2, whilst home range is 128-161km^2 for jaguars and 31.8 km^2 for pumas (Silveira 2004).

B2.1.2 Scat collection

Scats were collected in June 2007 along 188 km of trails and dirt roads in Cantão. Scats from Emas were also collected in the dry season, from May to July 2007, using the same methodology but conducted by another team. In order to maximize the probability of collecting scats from different individuals, determination of the routes took home range average size and jaguar density into consideration. Both sites were large enough to guarantee that numerous individuals contributed to the overall sample. Transects were never repeated in order to reduce probability of collecting scats from the same individual. Although standard methodologies were

adopted and despite the fact that collection of scats for ecological studies is a common and powerful tool (Trites & Joy 2005), sampling food habits based on faecal collection in an unbiased manner is difficult and some bias may have affected this study, since, nevertheless, more than one scat may refer to the same individual or to the same prey taken by one individual.

Information on previous use of travel routes was also taken into account, because jaguars use regular paths (Soisalo & Cavalcanti 2006), thus increasing the chance of acquiring an adequate sample size (to accurately depict the diet of jaguars, the recommended minimum number of scats is 25-35; Nuñez *et al.* 2000).

To reduce collection biases and to enhance sample acquisition rates (Wasser *et al.* 2004), a specially trained domestic dog was hired and used to collect scats. This recently developed non-invasive method has been demonstrated to be valuable as part of monitoring programmes over large remote areas, and it has been successfully applied to several species, such as San Joaquin kit foxes (study in which dogs were 100% accurate, as confirmed by DNA tests of 1298 collected scats) (Smith *et al.* 2003), grizzly and black bears (Wasser *et al.* 2004), bobcats (Harrison 2006), and black-footed ferrets (Reindl-Thompson *et al.* 2006). Scat collection by detection dogs has several advantages over researchers relying on visual detection because some subjects may deposit their scat more conspicuously than others, and sample acquisition is also enhanced by the sensitive sense of smell in canids, enabling detection of odours at distances over 0.4 km away (Wasser *et al.* 2004).

The dog was trained by professionals using scenting techniques similar to those for narcotics detection, and was chosen for its strong object orientation, high play drive, and willingness to strive for a reward.

Beginning at dawn, transects were searched for 5-7 hours, covering a 6 to 18km transect. The length of time that the dog was able to work was limited by temperature.

Although genetic analysis is the only technique available to distinguish scats of jaguar from puma with certainty, this method is expensive and has limited success due to degradation of target DNA, especially in tropical ecosystems (Farrell *et al.* 2000). Thus, and due to the inability of the dog to distinguish between jaguar and puma scats, the identity of the predator was assigned by the presence of tracks, as done by e.g. Rabinowitz and Nottingham (1986), Aranda and Sánchez-Cordero (1996), Núnez *et al.* (2000), Scognamillo *et al.* (2003). Scats without associated

tracks were considered as of big felid.

The dog handler confirmed scat identification by size, colour and odour. The minimum size for an adult jaguar scat is considered to be 19 mm (Farrell *et al.* 2000). To differentiate between scats of big cats (i.e. puma and jaguar) and other carnivores, the dimensions, structure, deposit site and nearby tracks were used. Scats deposited within 50m of each other and of similar age were pooled to one observation to ensure an independent scat sample. Scats were placed in plastic bags individually, and, following a protocol established for jaguars' nutritional ecology studies (Arizona Game and Fish Department 2006), for each scat, diameter, GPS location, date, identification, and site description were recorded.

B.2.1.3. Laboratory procedures

Laboratory procedures for scat analysis followed Ciucci *et al.* (1996). Following the standard methodology (Goszczynski 1974, Lockie 1959), scats were sun-dried, and each dried scat was washed and sieved under a jet of water (mesh size 0.5mm) to separate hairs from other identified macro-components.

Identification of remains followed Day (1966), determinating prey species by macroscopic identification of bones, teeth, scales and hooves, as well as microscopic analysis of hair microstructure according to the key by Quadros (2002). Techniques for microscopic examination followed Teerink (1991), obtaining cuticular impressions by pressing hairs against a varnish layer let dry for 15-20 minutes on glass slides, and submitting hairs to diafanization with comercial oxigenated water 30 volumes for 80 minutes. Hair cuticular and medullar characteristics were also compared with known specimens in a reference collection. Microscopic analysis allowed some differentiation but did not allow for unambiguous identification of all prey items to species level, mainly due to lack of a complete reference collection and lack of data on all species available in the study areas. Thus, in some cases, material in faeces was classified to a higher taxonomic level. For example, because distinction between white-lipped and collared peccary was not possible, in this study the term peccaries will be used to refer to the two species.

B.2.1.4. Estimation of diet composition

To assess the importance of food items in the diet, dietary composition was described as the frequency of occurrence (FO) of different food items expressed as

the percentage of the total number of scats, and the percentage of occurrence (PO) expressed as the percentage of the total number of occurrences of all food items in the diet (Ciucci *et al.* 1996). Analysis of prey species that differ considerably in size can result in overestimation of the amount of smaller mammals eaten relative to larger prey because smaller prey has a higher body surface:body volume ratio and is covered by more hair or feathers per unit mass of flesh relative to large prey; thus, in this study, diet composition is expressed in more than one way, because comparison of results from several methods helps to avoid misleading conclusions by relying on a single method (Ciucci *et al.* 1996).

Relative biomass of prey consumed was thus calculated following the method generally used in jaguar diet studies, to enable comparison of biomass consumed between studies. For prey weighing more than 2 kg, a correction factor (Y= 1.98 + 0.035 X) developed for pumas by Ackerman *et al.* (1984) was used, where Y is the weight of food consumed per scat and X is the weight of the live prey. Ackerman *et al.* (1984) has developed this correction factor by regressing prey biomass consumed per scat against live body weight of the prey animals to determine the relationship between body weight of prey and scats produced. For its application on jaguar, the assumption that the digestive systems of these large felids are similar followed e.g. Garla *et al.* (2001). This correction factor reduces overestimation of the relative importance of small prey in a predator diet. So, biomass consumed provides a more accurate representation of diet than either percentage of occurrence or frequency of occurrence (Ackerman *et al.* 1984, Karanth & Sunquist 1995).

Weights of prey items were obtained from Emmons (1997) and Núñez *et al.* (2000). Mammal prey were considered to be adult unless evidence to the contrary was found (e.g. size of hooves). Approximate weight of other prey was based on size of hard parts (e.g. turtle beak). When species identification was not possible, weight refered to the average of that group's most common species in the study area. Relative biomass of tapirs was extrapolated (Weaver 1993) because Ackerman *et al.*'s (1984) equation was derived for prey up to 70 kg.

The confidence limits of the estimated importance of different food types in the diet were measured with the 95-percentiles of 5000 bootstrap estimates as described in Reynolds and Aebischer (1991). A bias-corrected and accelerated (Bca) bootstrap was applied due to skewness of data (Manly 1997).

Fisher's exact test on number of prey items, arranged into the categories:

peccaries, Cervidae, armadillos, marsupials, reptiles, birds, carnivores, anteaters, primates, other small mammals (rodents + rabbits + porcupine), cattle, and other large mammals (capybara + tapirs), was used to determine if the diets of big cats differed between study areas. Differences in the relative frequency of prey consumed by big cats were tested with a Student's t-test for differences of proportions.

B.2.1.5. Mean weight of vertebrate prey

The mean weight of vertebrate prey (MWVP) was calculated as a grand geometric mean (Iriarte *et al.* 1990).

B.2.1.6. Food niche breath

The standardized food niche-breadth (B_{sta}) was calculated following Colwell and Futuyma (1971): $B_{sta}= (BO - B_{min})/(B_{max} – B_{min})$, where BO is the observed niche breadth (i.e., $BO= 1/\Sigma p^2i$, where pi is the relative occurrence of prey taxon i in the diet), B_{mix} is the minimum niche breadth (= 1), and B_{max} is the maximum possible niche breadth (the number of prey taxa taken).

This index of diet diversity has been used in other studies of puma and jaguar diets (e.g. Iriarte *et al.* 1990, Taber *et al.* 1997), and allows comparison among different regions and with different numbers of prey categories, ranging from 0 to 1 (a value close to 0 reflects specialization on a few prey categories, whereas a B_{sta} closer to 1 reflects more diversity in the diet) (Colwell & Futuyma 1971).

B2.1.7. Prey selectivity

Prey relative abundance used in this study was obtained by camera trapping. Photographic data of prey species has been used to estimate distribution and abundance of prey in several studies regarding large predators, such as tigers (*Panthera tigris;* O' Brien *et al.* 2003, Johnson *et al.* 2006), and jaguars (Wecket *et al.* 2006a), despite the fact that camera trapping may inflate the relative abundance of some species (Silveira *et al.* 2003), largely a consequence of camera placement (Carbone *et al.* 2001).

Data made available by the Jaguar Conservation Fund, from a systematic camera trap survey being conducted in the study areas since 2001 with the objective of surveying jaguar populations and estimating population densities of this species,

was used in the form of species-specific capture rates averaged across all camera locations. 30-40 cameras were placed in tracks usually used by jaguar, located 1.5-3 km apart and around 0.5 m off the ground (JCF 2006). Camera trapping and scat collection overlapped spatially. No independent assessment of animal density was made, so photographs could not be corrected to account for actual abundance (Carbone *et al.* 2001), and a relative abundance index of available prey expressed as number of occurrences per trap nights (Weckel *et al.* 2006a) was obtained.

Species whose presence was not confirmed by camera trapping, although known to occur in the area and found in the scats, were eliminated from this analysis.

The selectivity index (S) used to compare the abundance of edible prey species in the habitat and its proportion in the diet was calculated using: $S = (PCi – PAi)/(PCi + PAi)$, being PCi = proportion of one particular prey species in the diet as a percentage of the relative number of that prey species in the diet, and PAi = proportion of the same prey species available in the habitat as a percentage of the individual density of that prey species in total prey population (Khan 2004). S ranges from -1 (total avoidance of a species) to 0 (selection proportional to occurrence) to 1 (maximum positive selection).

B2.2. Biogeographical patterns in jaguar diet: literature review

B2.2.1 Source data and variables used

Data on jaguar diet was collected searching in ISI Science Citation Index database (available from Web of Science) for the keywords "jaguar AND diet", from 1900 to August 2007. All the articles detected in the journals *Journal of Zoology, Biological Conservation, Biotropica, Behavioural Ecology and Sociobiology,* and *Studies on Neotropical Fauna and Environment* were consulted. Data from the dissertation by Crawshaw (1995) was included, although not available in the University of Leeds library, because it describes the jaguar diet in a Brazilian tropical rainforest.

All studies were based on scat analysis and the raw data was described for comparative purposes. Other studies that were not published in peer-reviewed journals were excluded. Data from Novack *et al.* (2005) was split in two entries, because they considered two areas with different hunting pressure. The geographical distribution of these studies is shown in figure 2.4.

Diet composition was analysed from the frequency of occurrence data because it was the most commonly used method for expressing importance of food groups in all studies. To standardize data and reduce bias associated with frequencies of occurrence (Ciucci *et al.* 1996), diet composition was converted to relative biomass consumed (see section B.2.1.4. for details), when not available in this form in the original study. Weights of prey were obtained from the respective studies; otherwise, information from Emmons (1997) was used. MWVP was also calculated (see section B.2.1.5. for details) when not reported in the original study. In order to calculate the diet diversity for each location, the standardized food niche breath was used (see section B.2.1.6. for details).

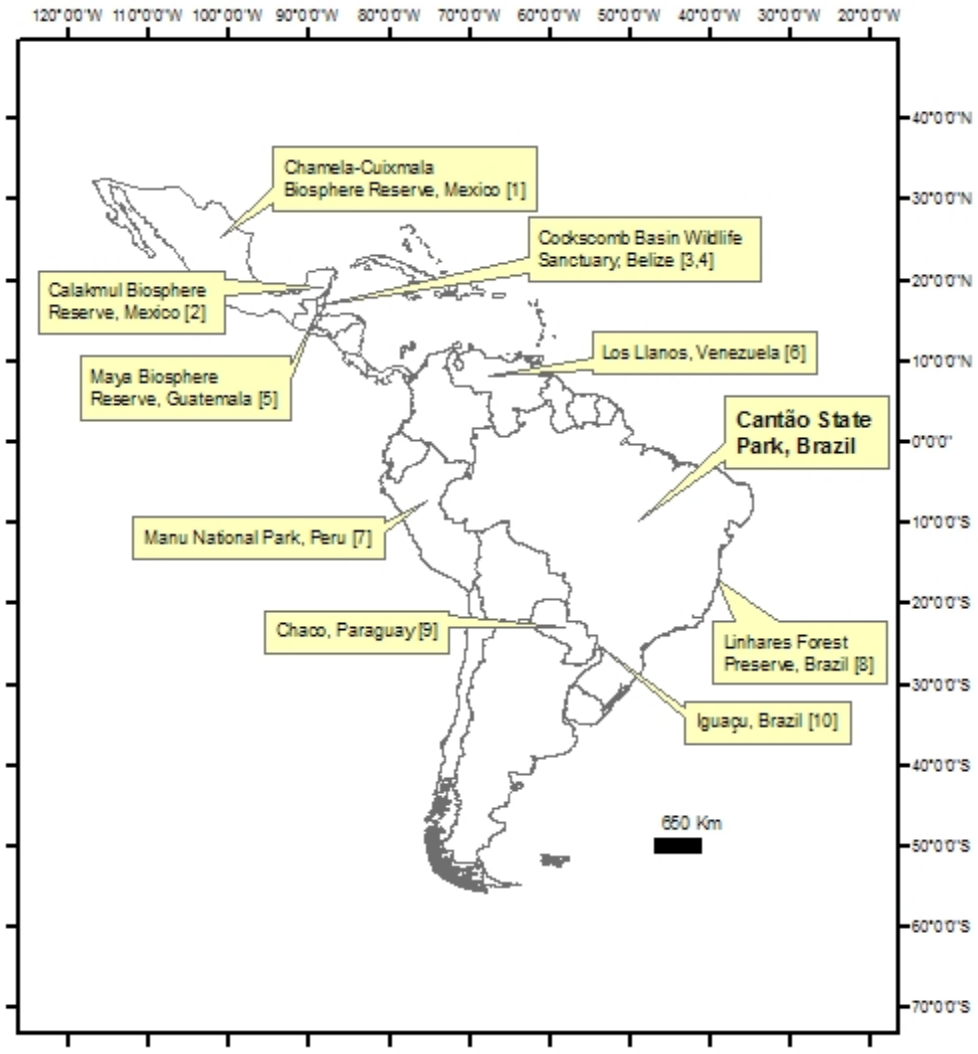

Figure 2.4. Geographic location of the reviewed studies and area of this study: [1] Núñez *et al.* 2000; [2] Aranda & Sánchez-Cordero 1996; [3] Rabinowitz & Nottingham 1986; [4] Weckel *et al.* 2006a; [5] Novack *et al.* 2005; [6] Scognamillo *et al.* 2003; [7] Emmons 1987; [8] Garla *et al.* 2001; [9] Taber e*t al.* 1997; [10] Crawshaw 1995.

Due to the small number of reported cases of predation by jaguar on certain species, and to homogenize the data for comparative purposes, prey were rearranged into the following categories: peccaries, Cervidae, armadillos, marsupials, reptiles, birds, carnivores, anteaters, primates, other small mammals, other large mammals. Prey were also grouped according to weight as: small (< 2 kg), medium (1-10 kg), and large (> 10 kg). For each of these weight categories, relative biomass consumed was calculated. For each area, habitat type, latitude, and area protection status were obtained from original source data. Number of scats, and method for identification of predator (laboratorial analyses versus tracks found in the field) were also considered.

B2.2.2. Statistical analyses

A Principal Component Analysis (PCA) was performed on the occurrence data to describe the jaguar overall trophic pattern across its distribution range, and PCA scores were used in place of the original variables.

To compare the agreement of occurrences on prey items from different locations, the Kendall's coefficient of concordance (W) was used. This is a measure of the agreement among several judges (locations) who are assessing a set of objects (prey groups). This statistic ranges from 0 (opportunist or generalist species) to 1 (specialist behaviour). For intermediate and facultative behaviours, K-values are near 0.5 (Virgós *et al.* 1999).

To avoid transformations due to non-normality, generalized linear models (GLM) were fitted to: factors obtained by PCA, standardized food niche breath (B_{sta}), and percentage of consumed biomass of small, medium and large prey. Predictors were: latitude, habitat type, and protection status. MWVP was also fitted to explain diet diversity. To check the effects of number of samples and predator identification method, they were also added as predictors of importance of diet components. For proportions, models were fitted employing quasibinomial error structure and logit link function, and for food niche breath and MWVP, GLMs were fitted using Gaussian error distribution and log link function (Crawley 2005). All predictors were fitted simultaneously and model selection was carried by stepwise removal of the least significant parameter. When reporting non-significant factors, values were obtained just before removal of that parameter from the model. Statistical analyses were performed using R v. 2.4.1 and were followed by residual analyses to check the suitability of the models and error distributions.

B3. Results

B3.1 Food habits of jaguar at Cantão State Park

A total of 62 scats were collected in Cantão, 25 of which were classified as of jaguar, while the remaining 37 were of unidentified big felid (jaguar or puma). Jaguar scats diameter ranged from 19 to 35 mm (26.6 ± 5.4 ; mean ± SD). Scat analysis revealed that jaguars utilized at least 16 prey species (Table 2.1), and scats contained 32 prey components for an average of 1.28 items per scat.

Mammals composed 84.4% of occurrence in the jaguar diet and 91.8% of biomass consumed. The most important prey of jaguars were ungulates, making up to 48.1% of biomass consumed, namely tapir (22.3%), peccaries (15.6%), and cattle calves (10.2%). Carnivores and monkeys also occurred in important proportions in the diet, representing 9.2% and 8.7% of total biomass, respectively. Opossums of the genus *Didelphis* were the most common prey item (15.6%), while peccaries, monkeys, and reptiles were also consumed frequently (12.5%). Peccaries were found in 16% of the scats, while 20% of the scats contained *Didelphis* sp. Birds were taken occasionally by the jaguar, as were a few other mammals (southern tamandua, porcupine, armadillo, giant anteater, and unidentified smaller opossums of the Didelphidae family).

Large mammals (> 10 kg) comprised 52% of biomass consumed and 28% of occurrence in the diet, medium-sized mammals (2-10 kg) comprised 31% of biomass consumed and 34% of occurrence, and small mammals (< 2 kg) comprised 9% of biomass consumed and 22% of occurrence. Mean weight of vertebrate prey (MWVP) consumed by jaguars was 5.37 kg. Width of the jaguar's standardized food niche breath was 0.76.

In addition to prey species identified in scat analysis, remains of a pink Amazon river dolphin *(Inia geoffrensis)* killed by a jaguar were found. Identification of predator was possible through tracks. This prey was not included in the analysis, since it was not found according to the adopted methodology.

Table 2.1. Relative importance of prey identified from jaguar faeces (n= 25) obtained in Cantão State Park, Brazil.

Prey species	Frequency of occurrence [a]		Percentage of occurrence		Percentage of biomass
	Sample estimate (scats = 25)	Bootstrap 95-percentile range	Sample estimate (items = 32)	Bootstrap 95-percentile range	Sample estimate
Large animals (>10kg)					
Peccaries	16.0	4.0 – 30.0	12.5	3.1 – 25.0	15.6
Brazilian Tapir (*Tapirus terrestris*)	8.0	0.0 – 20.0	6.3	0.0 – 15.7	22.3
Cattle calf	8.0	0.0 – 20.0	6.3	0.0 – 15.7	10.2
Giant anteater (*Myrmecophaga tridactyla*)	4.0	0.0 – 12.0	3.1	0.0 – 9.4	4.3
Medium-sized animals (2-10 kg)					
Monkeys Cebidae	12.0	3.0 – 27.0	12.5	3.1 – 25.0	8.7
Crab-eating fox (*Cerdocyon thous)*	8.0	0.0 – 20.0	6.3	0.0 – 15.7	6.1
Southern tamandua (*Tamandua tetradactyla)*	8.0	0.0 – 20.0	6.3	0.0 – 15.7	5.9
Crab-eating raccoon (*Procyon cancrivorus)*	4.0	0.0 – 12.0	3.1	0.0 – 9.4	3.1
Armadillo	4.0	0.0 – 12.0	3.1	0.0 – 9.4	2.8
Brazilian porcupine (*Coendou prehensilis*)	4.0	0.0 – 12.0	3.1	0.0 – 9.4	2.9
Medium-large bird	4.0	0.0 – 12.0	3.1	0.0 – 9.4	2.9
Small animals (< 2 kg)					
Opossums *Didelphis* sp	20.0	4.0 – 28.0	15.6	3.1 – 28.1	6.8
Other opossums Didelphidae	8.0	0.0 – 18.0	6.3	0.0 – 15.7	2.7
Snake	8.0	0.0 – 19.0	6.3	0.0 – 15.7	2.7
Caiman	4.0	0.0 – 12.0	3.1	0.0 – 9.4	1.4
Turtle	4.0	0.0 – 12.0	3.1	0.0 – 9.4	1.4

a Values do not add up to 100 because many scats had more than 1 prey item.

Tapirs were the most often photographed ungulate in Cantão, being the opossums and ocelots also relatively abundant in the study area (Table 2.2).

Jaguars apparently used southern tamanduas and giant anteaters greater than their availability (EI= 0.86 and 0.74, respectively), and exhibited avoidance of tapir (EI= -0.71), and complete avoidance of other felids, coatis, deers, agoutis, and capybaras (EI= -1). Opossums, peccaries, and crab-eating foxes were consumed in similar proportions to their availability.

Table 2.2 Jaguar prey use, availability and selection in Cantão State Park, Brazil. Strong positive selection is shown in bold.

Species	Prey use[a]	Prey available[b]	SI[c]
Opossums *Didelphis* sp	15.6	11.4	0.16
Peccaries	12.5	7.1	0.27
Brazilian Tapir (*Tapirus terrestris*)	6.3	36.2	-0.71
Crab-eating fox (*Cerdocyon thous)*	6.3	5.2	0.09
Southern tamandua (*Tamandua tetradactyla)*	6.3	0.5	**0.86**
Giant anteater (*Myrmecophaga tridactyla*)	3.1	0.5	**0.74**
Ocelot (*Leopardus pardalis*)	0	13.3	-1
Red brocket deer (*Mazama americana)*	0	8.6	-1
Paca *(Agouti paca)*	0	7.6	-1
Azara's agouti (*Dasyprocta azarae*)	0	3.3	-1
Grey brocket deer (*Mazama gouazoubira*)	0	2.9	-1
Jaguarundi (*Herpailurus yagouaroundi)*	0	1.4	-1
Capybara (*Hydrochoerus hydrochaeris*)	0	1.0	-1
Coati *(Nasua nasua)*	0	1.0	-1

[a]Diet constructed from 25 scats and expressed as percentage of occurrence. Prey use is not presented for species with no reliable abundance estimation.

[b]Photographic capture rates expressed as number of captures per 100 trap nights.

[c] Selectivity index .

B3.2 Comparison of big cats' diet between study areas

A total of 62 scats of big felid (25 jaguar scats and 37 of unidentified big cat) were collected in Cantão and their diameter ranged from 19 to 35 mm (25.2 ± 4.8 ; mean ± SD). Scats contained 84 prey components for an average of 1.35 items per scat. Big cats preyed on at least 24 prey species (Table 2.3), and peccaries, red brocket deers and tapirs were the most important components of the diet in Cantão, contributing 13.6%, 10.1% and 9.7% to the biomass consumed, respectively. Cattle calves were important secondary components, contributing considerably to the biomass consumed, as well as monkeys.

Mammals comprised 77.3% of occurrence and 87.7% of biomass consumed, while reptiles comprised 14.4% of all prey items. Small mammals constituted 29.7% of occurrence and 15.6% of biomass consumed, medium-sized mammals constituted 22.6% of occurrence and 23.2% of biomass consumed, and large mammals constituted 25% of occurrence and 52.4% of biomass consumed. Width of big cat's prey standardized niche was 0.79. Mean weight of vertebrate prey consumed by big cats in Cantão was 2.85 kg.

A total of 32 scats of unidentified big felid from Emas were analysed. Scats contained 44 prey components for an average of 1.38 items per scat. Big cats preyed on, at least, 11 prey species (Table 2.4). Giant anteaters and armadillos were the most important components of the diet in Emas, contributing 27.9% and 26.6% to the biomass consumed, respectively, followed by peccaries, which contributed 11.0%. Giant anteaters and armadillos were taken with the same frequency (each constituted 22.7% of all food items).

Small mammals constituted 29.5% of occurrence and 17.3% of biomass consumed, medium-sized mammals constituted 22.7% of occurrence and 26.6% of biomass consumed, and large mammals constituted 38.6% of occurrence and 48.0% of biomass consumed. Snakes and birds were taken occasionally (4.5% of occurrence each). Width of big cat's prey standardized niche was 0.6. Mean weight of vertebrate prey consumed by big cats in Emas was 35.18 kg.

Table 2.3. Relative importance of prey identified from big cat faeces (n= 62) obtained in Cantão State Park, Brazil.

Prey species	Frequency of occurrence [a]		Percentage of occurrence		Percentage of biomass
	Sample estimate (scats = 62)	Bootstrap 95-percentile range	Sample estimate (items = 84)	Bootstrap 95-percentile range	Sample estimate
Large animals (>10kg)					
Peccaries	12.9	4.8 – 20.2	9.5	3.6 – 15.6	13.6
Red brocket deer *(Mazama americana)*	8.1	1.6 – 13.7	6.0	1.2 – 11.9	10.1
Cattle calf	6.5	0.0 – 11.3	4.8	1.2 – 9.5	9.0
Brazilian Tapir (*Tapirus terrestris*)	3.2	0.0 – 8.1	2.4	0.0 - 6.0	9.7
Giant anteater (*Myrmecophaga tridactyla*)	3.2	0.0 – 7.3	2.4	0.0 – 6.0	3.7
Medium-sized animals (2-10kg)					
Monkeys Cebidae	11.3	2.9 – 15.8	8.3	2.4 – 14.3	8.9
Medium-large bird	9.7	2.6 – 14.0	7.1	2.4 – 13.1	7.5
Crab-eating fox (*Cerdocyon thous)*	4.8	0.5 – 8.6	3.6	0.0. - 7.1	4.0
Southern tamandua (*Tamandua tetradactyla)*	4.8	0.8 – 10.5	3.6	0.0 – 7.1	3.8
Paca (*Agouti paca*)	3.2	0.0 – 4.0	2.4	0.0 – 6.0	2.6
Crab-eating raccoon (*Procyon cancrivorus)*	1.6	0.0 -4.8	1.2	0.0 – 3.6	1.4
Brazilian porcupine (*Coendou prehensilis*)	1.6	0.0 – 1.6	1.2	0.0 – 3.6	1.3
Armadillo	1.6	0.0 – 4.8	1.2	0.0 – 3.6	1.2
Small animals (<2kg)					
Muridae	11.3	3.8 – 18.3	8.3	2.4 – 14.3	4.2
Opossums *Didelphis* sp	11.3	2.4 – 13.7	8.3	2.4 – 14.3	4.2
Other opossums Didelphidae	9.7	2.4 – 14.2	7.1	2.4 – 13.1	3.6
Turtle	8.1	0.8 – 10.5	6.0	1.2 – 11.9	3.0
Unidentified small rodent	4.8	0.4 – 8.9	3.6	0.0 – 7.1	1.8
Snake	4.8	0.4 – 8.9	3.6	0.0 – 7.1	1.8
Lizard	4.8	0.0 – 4.8	3.6	0.0 – 7.1	1.8
Spiny rat	3.2	0.0 – 8.1	2.4	0.0 – 6.0	1.2
Azara's agouti (*Dasyprocta azarae)*	1.6	0.0 – 4.8	1.2	0.0 – 3.6	0.6
Caiman	1.6	0.0 – 2.4	1.2	0.0 – 3.6	0.6
Crab	1.6	0.0 – 2.4	1.2	0.0 – 3.6	0.6

a Values do not add up to 100 because many scats had more than 1 prey item.

Table 2.4. Relative importance of prey identified from big cat faeces (n= 32) obtained in Emas National Park, Brazil.

Prey species	Frequency of occurrence [a]		Percentage of occurrence		Percentage of biomass
	Sample estimate (scats = 32)	Bootstrap 95-percentile range	Sample estimate (items = 44)	Bootstrap 95-percentile range	Sample estimate
Large animals (>10kg)					
Giant ant-eater (*Myrmecophaga tridactyla*)	31.3	10.9 – 37.5	22.7	11.4 – 34.1	27.9
Peccary	12.5	3.1 – 25.0	9.1	2.3 – 18.2	11.0
Cervidae	6.3	0.0 – 7.8	4.5	0.0 – 11.4	5.7
Brazilian Tapir (*Tapirus terrestris*)	3.1	0.0 – 9.4	2.3	0.0 – 6.8	3.4
Medium-sized animals (2-10 kg)					
Armadillo *Dasypus* sp	31.3	10.9 – 37.5	22.7	11.4 – 34.1	26.6
Medium-large bird	6.3	0.0 – 7.8	4.5	0.0 – 11.4	5.3
Small animals (<2 kg)					
Opossums *Didelphis* sp	15.6	3.1 – 25.0	11.4	2.3 – 20.4	6.6
Muridae	12.5	1.6 – 20.3	9.1	2.3 – 18.2	5.3
Other opossums Didelphidae	6.3	0.0 – 14.1	4.5	0.0 – 11.4	2.7
Snake	6.3	0.0 – 7.0	4.5	0.0 – 11.4	2.7
Unidentified small rodent	6.3	0.0 – 4.7	4.5	0.0 – 11.4	2.7

[a] Values do not add up to 100 because many scats had more than 1 prey item.

A comparison of number of prey items grouped into peccaries, Cervidae, armadillos, marsupials, reptiles, birds, carnivores, anteaters, primates, other small mammals, cattle, and tapirs, revealed that big cats diets differed between study areas (Fisher's exact test, p= 0.0003).

Although big cats consumed similar proportions of tapirs (t=0.25, p=0.804), peccaries (t=1.19, p= 0.235), deers (t=0.74, p= 0.459), marsupials (t=0.04, p=0.971), birds (t=-0.63, p=0.526), and other small mammals (t=-0.84, p=0.405), in Emas they consumed more armadillos (t=-6.34, p< 0.001), and anteaters (t=2.44, p=0.018). In Cantão, big cat scats had more reptiles (t=-1.99, p=0.048), carnivores (t=-2.05, p=0.044), monkeys (t=-2.76, p=0.007), and livestock (t=-2.31, p=0.024).

In Emas, peccaries were the most often photographed species, followed by tapirs, crab-eating foxes, deers and giant anteaters (Table 2.5).

In Cantão, big cats apparently preyed selectively upon tamanduas and giant anteaters, took tapirs and agoutis less than expected, and killed peccaries, opossums, deers and crab-eating foxes in proportion to availability. Complete avoidance was shown towards other felids, coatis, and capybaras. In Emas, big cats apparently took giant anteaters approximately in proportion to availability, took peccaries, deers and tapirs less than expected, and selected for opossums and armadillos. Complete avoidance of other carnivores, tamanduas, agoutis, and capybaras was exhibited.

Table 2.5. Prey use, availability and selection by big cats in Cantão State Park and Emas National Park, Brazil. Strong positive selection is shown in bold. NA refers to lack of abundance estimation, although the species is know to occur in the study area.

Species	Cantão			Emas		
	Prey use	Prey available	EI	Prey use	Prey available	EI
Peccaries	9.5	7.1	0.14	9.1	29.7	-0.53
Opossums *Didelphis* sp	8.3	11.4	-0.16	11.4	0.2	**0.97**
Cervidae	6.0	11.5	-0.31	4.5	12.1	-0.42
Crab-eating fox (*Cerdocyon thous)*	3.6	5.2	-0.18	0	13.2	-1
Southern tamandua (*Tamandua tetradactyla)*	3.6	0.5	**0.76**	0	0.5	-1
Giant anteater (*Myrmecophaga tridactyla*)	2.4	0.5	**0.66**	22.7	12.0	0.31
Brazilian Tapir (*Tapirus terrestris*)	2.4	36.2	-0.88	2.3	13.5	-0.74
Paca (*Agouti paca)*	2.4	7.6	-0.52	0	0.3	-1
Azara's agouti (*Dasyprocta azarae*)	1.2	3.3	-0.47	0	1.3	-1
Armadillo	1.2	NA	NA	22.7	4.7	**0.66**
Crab-eating raccoon (*Procyon cancrivorus)*	1.2	NA	NA	0	0.9	-1
Capybara (*Hydrochoerus hydrochaeris*)	0	1.0	-1	0	1.0	-1
Ocelot (*Leopardus pardalis*)	0	13.3	-1	0	1.7	-1
Jaguarundi (*Herpailurus yagouaroundi)*	0	1.4	-1	0	0.1	-1
Coati (*Nasua nasua*)	0	1.0	-1	0	1.5	-1
Grison *(Galictis vittata)*	0	NA	NA	0	0.2	-1
Tayra *(Eira barbara)*	0	NA	NA	0	0.5	-1
Striped hog-nosed skunk (*Conepatus semistriatus)*	0	NA	NA	0	1.6	-1
Pampas cat *(Oncifelis colocolo)*	0	NA	NA	0	1.4	-1
Hoary fox *(Lycalopex vetulus)*	0	NA	NA	0	2.3	-1

B3.3. Biogeographical patterns in jaguar diet: literature review

Across its geographic distribution, jaguars prey on a condiderable variety of species, and a comparative analysis of the published literature indicates that peccaries and armadillos may be essential prey, since each was the most frequent prey in 4 out of 10 articles (Table 2.6).

Table 2.6. Frequency of occurrence of prey items in the diet of jaguars in several locations. Most frequent prey for a certain study area is shown in bold.

Site	Jalisco [1]	CBR [2]	Belize [3]	Belize [4]	MBR [5]	MBR [5]	Llanos [6]	MNP [7]	LFP [8]	Chaco [9]	Iguaçu [10]
Habitat type [a]	Dry	Dry	Humid	Humid	Humid	Humid	Dry	Humid	Humid	Dry	Humid
Protection status [b]	P	P	NP	P	NP	P	NP	P	P	NP	P
N scats	50	37	228	23	23	53	42	25	101	106	73
Prey items											
Anteaters	-	2	9.3	-	-	1.89	10	4	-	3	-
Armadillos	18	12	**54**	**33.3**	**39.13**	**54.72**	-	-	30.93	7.4	8.5
Birds	4	10	1	-	-	5.66	2	16	3.94	2.2	8.5
Capybara	-	-	-	-	-	-	21	4	1.97	-	-
Carnivores	22	18	2	6.6	**39.13**	28.3	5	4	31.07	0.7	7.5
Cattle	-	-	-	-	-	-	7	-	-	-	-
Cervidae	**52**	8	6.5	6.7	4.35	15.1	5	8	3.94	23	8.5
Marsupials	2	-	4.2	-	-	-	4.2	8	-	10.4	9.4
Peccaries	20	**42**	5.4	26.6	32.77	16.98	**40**	24	**37.96**	4.4	**35.8**
Primates + Sloth	-	4	-	-	8.7	-	-	4	4.92	-	0.9
Reptiles	8	-	3	-	-	-	7	**52**	13.92	2.2	6.6
Rodents + Rabbits + Porcupine	-	4	14.6	23.3	21.74	15.1	2	24	9.84	**42.3**	7.5
Tapir	-	-	-	-	-	-	-	-	0.98	1.5	-

[a] Habitat type was classified as "dry" if it was a tropical dry forest, and "humid" if it was a tropical rainforest.

[b] Study area was classified as protected (P) or not protected (NP).

[1] Jalisco, Mexico (Núñez *et al.* 2000); [2] Calakmul, Mexico (Aranda & Sánchez-Cordero 1996); [3] and [4] Cockscomb Basin Wildlife Sanctuary, Belize (Rabinowitz & Nottingham 1986, Wecket *et al.* 2006b); [5] Maya Biosphere Reserve, Guatemala (Novack *et al.* 2005); [6] Los Llanos, Venezuela (Scognamillo *et al.* 2003); [7] Manu National Park (Emmons 1987); [8]Linhares Preserve Forest, Brazil (Garla *et al.* 2001);[9] Paraguayan Chaco (Taber *et al.* 1997); [10] Iguaçu, Brazil (Crawshaw 1995).

The Principal Component Analysis from the prey occurrence data generated three factors that explain 80.7% of the total variance in the diet of jaguars across their geographic range (Table 2.7).

The first factor shows a gradient from diets in which armadillos and carnivores have high importance towards others where marsupials have high proportions. The second factor shows a gradient from diets with high proportions of anteaters towards others where other large mammals (capybara, tapirs and livestock) were more important. The third factor describes diets with a high frequency of peccaries, primates and larger animals (capybara, tapirs and livestock) towards those with an important contribution of small mammals (rodents + rabbits + porcupine).

Jaguars show a opportunist or generalist behaviour, as shown by the value of the coefficient of concordance of diet composition between locations (K = 0.03).

Table 2.7. Correlations between prey items considered in this study and the factors from a Principal Component Analysis with varimax rotation (n= 11). Strong correlation (|loadings| > 0.50) is shown in bold.

Prey items	Factor 1	Factor 2	Factor 3
Anteaters	-0.006	**0.995**	0.044
Armadillos	**0.940**	-0.081	-0.275
Birds	0.009	-0.274	-0.077
Carnivores	**0.901**	-0.319	0.285
Cervidae	0.008	-0.327	-0.200
Marsupials	**-0.579**	-0.143	-0.198
Peccaries	-0.141	-0.257	**0.683**
Primates	0.029	0.078	**0.570**
Reptiles	0.157	0.094	0.417
Other small mammals	-0.123	-0.189	**-0.555**
Others	-0.318	**-0.691**	**0.516**
Eigenvalue	2.66	2.56	1.64
% Explained variance	42.9	22.4	15.5

Jaguar diet diversity, as measured by standardized food niche breadth, had a negative effect along the South-North gradient and was also significantly affected by the number of samples collected (Table 2.8). No significant effect of MWVP, habitat type, area protection status, distance from equator, nor predator identification method was found (Table 2.9).

Table 2.8. Parameter estimates from the best generalized linear model fitted to standardized food niche breath. Null deviance: 0.642.

Parameters	Estimate	Std. Error	t	Δ Residual deviance	p
Standardized food niche breadth					
Number of scats	-0.006	0.001	-4.78	0.469	0.001
Latitude (gradient South- North)	-0.007	0.003	-2.55	0.119	0.034

Table 2.9. Parameter estimates of the variables removed from the generalized linear model fitted to standardized food niche breadth. Null deviance: 0.642.

Parameters	Estimate	Std. Error	t	Δ Residual deviance	p
Standardized food niche breadth					
Habitat: Tropical rainforest	-0.184	0.101	-1.82	0.035	0.105
Latitude (|distance from equator|)	-0.016	0.009	-1.79	0.027	0.117
MWVP	-0.005	0.004	-1.19	0.011	0.278
Protection status: Protected	-0.059	0.110	-0.54	0.002	0.614
Method: Tracks	0.068	0.132	0.52	0.003	0.633

Mean weight of vertebrate prey is negatively affected by distance from the equator and is also significantly lower in rainforests than in tropical dry forests (Table 2.10). No significant effect of number of scats, predator identification method, protection status or gradient South-North was found (Table 2.11).

Table 2.10. Parameter estimates from the best generalized linear model fitted to mean weight of vertebrate prey. Null deviance: 100.

Parameters	Estimate	Std. Error	t	Δ Residual deviance	p
MWVP					
Habitat: Tropical rainforest	-1.180	0.288	-4.10	50	0.003
Latitude (|distance from equator|)	-0.079	0.030	-2.64	21	0.027

Table 2.11. Parameter estimates of the variables removed from the generalized linear model fitted to mean weight of vertebrate prey. Null deviance: 100.

Parameters	Estimate	Std. Error	t	Δ Residual deviance	p
MWVP					
Number of scats	-0.004	0.006	-0.63	1.6	0.549
Method: Tracks	0.180	0.467	0.39	0.6	0.711
Protection status: Protected	-0.095	0.372	-0.25	0.2	0.805
Latitude (gradient South- North)	0.002	0.012	0.20	0.2	0.850

Importance of large animals in jaguar diet was negatively affected by location in rainforest, number of analysed scats, and also decreased significantly along a gradient South-North (Table 2.12). These factors had also significant effects on the importance of medium-sized animals in the diet, however in opposite directions (Table 2.13). Distance from equator, protected status, and predator identification method did not affect any of the prey weight categories (Table 2.14, 2.15).

Table 2.12. Parameter estimates from the best generalized linear model fitted to percentage of biomass consumed of large animals (>10kg). Null deviance: 0.9.

Parameters	Estimate	Std. Error	t	Δ Residual deviance	p
Percentage of biomass consumed of large animals					
Habitat: Tropical rainforest	-0.484	0.167	-2.91	0.3	0.020
Number of scats	-0.005	0.002	-2.51	0.3	0.036
Latitude (gradient South- North)	-0.011	0.005	-2.17	0.2	0.061

Table 2.13. Parameter estimates from the best generalized linear model fitted to percentage of biomass consumed of medium-sized animals (2-10kg). Null deviance: 1.78.

Parameters	Estimate	Std. Error	t	Δ Residual deviance	p
Percentage of biomass consumed of medium-sized animals					
Habitat: Tropical rainforest	0.926	0.325	2.85	0.53	0.021
Latitude (gradient South- North)	0.018	0.007	2.62	0.39	0.030
Number of scats	0.003	0.001	2.36	0.27	0.046

Table 2.14. Parameter estimates of the variables removed from the generalized linear model fitted to percentage of biomass consumed of large animals. Null deviance: 0.9.

Parameters	Estimate	Std. Error	t	Δ Residual deviance	p
Percentage of biomass consumed of large animals					
Method: Tracks	0.282	0.149	1.89	0.1053	0.101
Latitude (|distance from equator|)	-0.005	0.017	-0.30	0.0030	0.526
Protection status: Protected	0.028	0.335	0.08	0.0003	0.939

Table 2.15. Parameter estimates of the variables removed from the generalized linear model fitted to percentage of biomass consumed of medium-sized animals. Null deviance: 1.78.

Parameters	Estimate	Std. Error	t	Δ Residual deviance	p
Percentage of biomass consumed of medium-sized animals					
Method: Tracks	-0.433	0.231	-1.88	0.143	0.102
Latitude (|distance from equator|)	0.027	0.027	0.99	0.040	0.360
Protection status: Protected	-0.062	0.306	-0.20	0.002	0.847

Importance of small animals in jaguar diet along its range in terms of biomass was best explained by a model including latitude, expressed as a gradient from South to North, and habitat type. In tropical rainforests, small animals were marginally significant less important to jaguar diet than in tropical dry forests (Table 2.16). None of the other considered predictors had any significant effect on this prey weight category (Table 2.17).

Table 2.16. Parameter estimates from the best generalized linear model fitted to percentage of biomass consumed of small animals (<2kg). Null deviance: 0.66.

Parameters	Estimate	Std. Error	t	Δ Residual deviance	p
Percentage of biomass consumed of small animals					
Latitude (gradient South- North)	-0.050	0.011	-4.39	0.40	0.002
Habitat: Tropical rainforest	-0.751	0.361	-2.08	0.07	0.067

Table 2.17. Parameter estimates of the variables removed from the generalized linear model fitted to percentage of biomass consumed of small animals. Null deviance: 0.66.

Parameters	Estimate	Std. Error	t	Δ Residual deviance	p
Percentage of biomass consumed of small animals					
Method: Tracks	0.842	0.535	1.57	0.04459	0.154
Latitude (|distance from equator|)	-0.059	0.037	-1.60	0.04528	0.153
Protection status: Protected	-0.657	0.918	-0.72	0.00999	0.501
Number of scats	-0.001	0.010	-0.06	0.00007	0.958

No significant effect of food niche breath, latitude, habitat, protection status, number of scats and predator identification method was found for any of the diet components obtained by PCA (Tables 2.18, 2.19, 2.20).

Table 2.18. Parameter estimates of the variables removed from the generalized linear model fitted to scores from principal component 1. Null deviance: 5.849.

Parameters	Estimate	Std. Error	t	Δ Residual deviance	p
Principal Component 1					
Number of scats	0.013	0.010	1.29	1.003	0.229
Latitude (gradient South- North)	0.029	0.025	1.16	0.658	0.271
Habitat: Tropical rainforest	0.427	1.271	0.34	0.091	0.747
Protection status: Protected	-0.345	1.170	-0.29	0.043	0.778
Latitude (|distance from equator|)	0.025	0.143	0.17	0.025	0.869
Food niche breadth	1.131	11.133	0.10	0.007	0.924
Method: Tracks	0.085	2.049	0.04	0.002	0.969

Table 2.19. Parameter estimates of the variables removed from the generalized linear model fitted to scores from principal component 2. Null deviance: 1.52.

Parameters	Estimate	Std. Error	t	Δ Residual deviance	p
Principal Component 2					
Number of scats	-0.005	0.005	-1.05	0.15	0.319
Latitude (gradient South- North)	-0.019	0.021	-0.94	0.12	0.383
Protection status: Protected	-0.809	0.931	-0.87	0.11	0.414
Habitat: Tropical rainforest	0.601	0.823	0.73	0.09	0.498
Method: Tracks	0.436	0.509	0.86	0.09	0.414
Food niche breadth	-1.760	2.554	-0.69	0.06	0.510
Latitude (|distance from equator|)	-0.045	0.113	-0.40	0.03	0.708

Table 2.20. Parameter estimates of the variables removed from the generalized linear model fitted to scores from principal component 3. Null deviance: 2.199.

Parameters	Estimate	Std. Error	t	Δ Residual deviance	p
Principal Component 3					
Number of scats	-0.008	0.005	-1.52	0.435	0.160
Method: Tracks	0.609	0.502	1.21	0.240	0.256
Protection status: Protected	-0.772	0.773	-1.00	0.161	0.347
Latitude (|distance from equator|)	-0.017	0.065	-0.26	0.012	0.801
Latitude (gradient South- North)	-0.005	0.029	-0.18	0.008	0.862
Food niche breadth	-0.534	3.556	-0.15	0.005	0.885
Habitat: Tropical rainforest	0.055	0.904	0.06	0.001	0.95

B4. Discussion

As might be expected from its distribution, jaguar showed a great diversity in feeding ecology. The most important prey components in Cantão jaguar diet were opossums, peccaries and monkeys, in terms of frequency of occurrence, or tapirs, peccaries, and cattle calves, in terms of biomass consumed. Apparently, in Cantão, jaguars exhibited positive selectivity towards anteaters, while consuming opossums, peccaries, and crab-eating foxes in similar proportions to their availability.

Big cats in Emas and Cantão had significantly different diets, exhibiting preference for larger prey in Emas. No livestock remain was found in scats from Emas, while in Cantão cattle calves were an important diet component of big cats.

Latitude and habitat type seem to be important factors explaining jaguar diet variability along its range, although the number of scats analysed in several studies may be affecting results, being positively correlated with percentage of consumed biomass of medium-sized animals, and negatively correlated with percentage of consumed biomass of large animals.

B4.1. Jaguar diet

Cantão jaguars consumed more frequently opossums, peccaries and monkeys, being tapirs, peccaries, and cattle calves the more important prey in terms of biomass contribution.

Peccaries have already been reported as an important prey species for jaguars across habitat types (Aranda & Sánchez-Cordero 1996, Garla *et al.* 2001, Scognamillo *et al.* 2003, Novack *et al.* 2005) with the geographic distribution of peccaries suggested as a factor limiting the current range of jaguars (Novack *et al.* 2005).

Presence of opossums and monkeys in jaguar diet has frequently been reported before (e.g. Crawshaw 1995, Taber *et al.* 1997, Novack *et al.* 2005), although in less important proportions. Scats with remains of monkeys were found mainly in the forested areas of Cantão, where sightings of capuchin monkeys and squirrel monkeys occurred more often, suggesting that the jaguar may be preying on a resource that is abundant.

Tapirs were rarely reported as jaguar prey and its importance in this study may be overestimated due to small sample size. The two scats with remains of tapir were found 18.1 km apart and they were considered two independent samples. It is

not possible to say however that they were really two different individual preys or even that the jaguar killed it. Overestimation of tapir's importance in this study is also suggested by the significantly less important percentage of large animals consumed biomass in tropical rainforests than in tropical dry forests. On the other hand, it is possible that tapirs are just more abundant in Cantão than in the other studies areas.

Use of livestock as prey by jaguars is also described, specially for areas close to deforestation borders such as the study area, where large felifs often shift from natural to livestock prey because of their increased proximity to human agriculture (Michalski *et al.* 2006).

This study is also in accordance to previous studies in which jaguars were reported to make use of habitats along rivers and lakes, hunting on aquatic species (Emmons 1987). Turtle and caiman were found in the scats and a pink dolphin killed by jaguar was also found, confirming use of aquatic prey by jaguar. In a seasonally flooded area such as Cantão, aquatic prey may be essential for jaguar survival in the wet season, when jaguars and prey species are thought to move to surrounding areas.

It has been suggested that jaguars were not dependent on large prey (González & Miller 2002), what is supported by this study, because jaguars also used medium-sized prey intensively, such has been reported for leopards (Hayward *et al*. 2006a), cheetahs (Hayward *et al*. 2006b), and pumas (Iriarte *et al.* 1990).

B4.1.1. Jaguar prey selectivity

Several studies have shown that jaguars exhibit species-specific prey selection (Emmons 1987, Novack *et al.* 2005). As observed for jaguars in other studies (Emmons 1987, Novack *et al.* 2005, Wecket *et al.* 2006a), Cantão jaguars exhibited selective tendencies in discriminating among larger prey items.

Jaguars consumed peccaries approximately in the same proportion as their availability, and avoided tapirs and deers, while positively selecting giant anteaters. Associated risks and long handling times probably explain why jaguars preyed on tapir less than expected, and may explain why tapirs are rarely reported as important jaguar prey. Although in this study both peccaries were treated as the same prey group, Weckel *et al.* (2006a) have reported jaguar avoidance towards white lipped peccary, while positively selecting collared peccary, probably because white lipped peccaries travel in large aggressive herds. Positive selection on giant anteaters may be related to its solitary behaviour and slow movement (Collevatti *et al.* 2007), whilst

representing a considerable energetic gain for the jaguar, weighing from 29 to 65 kg, despite potential conflicts due to the giant anteater's powerful claws.

However, camera trapping in Cantão did not allow to estimate relative abundance of several prey species such as monkeys, birds, and reptiles, probably not only due to arboreal behaviour of some of these species, but also due to animal size or due to avoidance of areas in which cameras had been placed. Thus, prey selectivity results from this study have to be carefully interpreted (see section 4.3. for detailed discussion on methods).

B4.1.2. Factors affecting jaguar diet variability

Although González and Miller (2002) have suggested that jaguars living farther away from the equator used large prey (>10 kg) more frequently, whereas jaguars living nearer the equator depended more heavily on medium-sized prey (1- 10 kg), no significant effect of distance from the equator was found on percentage of consumed mass on any of the prey weight categories. By the contrary, distance from the equator seems to have a negative effect on mean weight of vertebrate prey, suggesting that jaguar may use larger prey near the equator.

A gradient from southern to northern jaguar distribution areas was found to be negatively correlated with standardized food niche breadth, percentage of consumed biomass of large and small animals, and positively correlated with percentage of consumed biomass of medium-sized animals. This suggests that southern jaguars rely mainly on large prey, using several species of small prey as secondary items, resulting in a more diverse diet, while northern jaguars depend mainly on medium-sized prey. This may be related not only to prey availability, abundance, and distribution, but also to differences in jaguar size. As an example, jaguars from Pantanal, Brazil, were reported to be bigger (Crawshaw & Quigley 1991), and it is possible that their size changes considerably between study areas, thus reflecting in their food habits.

Although it has been suggested that use of medium-sized prey by jaguars may be associated with human disturbance (Novack *et al.* 2005), no significant effect of area protection status was found in this study. This obviously does not mean that protection has no effect on jaguar diet, specially because it is extremely difficult to compare protection status between different countries, and in areas with different human impacts. Moreover, jaguar show a preference for tree cover (Crawshaw &

Quigley 1991), a close association with water (Sunquist & Sunquist 2002), and an avoidance of very disturbed habitat (Quigley & Crawshaw 1992). So their existence at the study areas might already be indicative of a similar conservation status.

In tropical rainforests, mean weight of vertebrate prey was significantly lower, as well as percentage of consumed biomass of large and small animals, whilst percentage of consumed biomass of medium-sized animals was significantly higher than in tropical dry forests. A similar situation has been observed for the puma (Iriarte *et al.* 1990), who take fewer large prey in less open habitats, probably due to low visibility and fewer predictable sites for prey aggregation in tropical rainforests (Scognamillo *et al.* 2003). In rainforests jaguars may thus depend mainly on medium-sized prey.

If jaguar diet in tropical rainforests reflected mainly chance encounters, contrary to what happens in more open habitat (Scognamillo *et al.* 2003), it would be expected that diet in those areas would be much more diverse, reflecting the biodiversity found there. Yet no significant effect of habitat type on diet diversity was found, as measured by standardized food niche breadth. So this supports other studies showing that jaguars exhibit species-specific prey selection (Emmons 1987, Novack *et al.* 2005).

B4.2. Big cats diet: comparison between two study areas

Although several variables may confound comparison of big cats diet between Cantão and Emas, differences in prey importance are evident. Both study areas were surrounded by ranches, yet in Emas no remain of livestock was found in the scats.

Attacks by big cats on livestock in Emas have been reported before, but the sample size may had been too small to detect their occurrence. It is also possible that big cats in Cantão prey on livestock more often than in Emas because abundance of large preys is higher in Emas, specially peccaries and giant anteaters. Tapirs were less abundant in Emas but this prey has rarely been reported as big cat prey.

Likewise, large prey could be more easily caught by big cats in Emas than in Cantão, where occur low visibility and fewer predictable sites for prey, characteristics of a forested habitat. Thus, maybe in Cantão livestock is a more cost-efficient large prey to capture. However, minor prey items may not have been observed due to small sample size from Emas.

It has been suggested that the size of sympatric carnivore species correlates positively with prey size, with larger species taking larger prey (Rosenzweig 1966). Pumas have been reported to be larger at higher latitudes (Iriarte *et al.* 1990) and, although this has not yet been investigated for jaguars, differences in predator size between study areas may occur, explaining differences in diet.

Several studies have reported armadillo as the most frequently consumed jaguar prey, even in areas where peccaries were abundant (e.g. Novack *et al.* 2005), suggesting a regional importance of armadillo to jaguar diet regardless of the availability of other prey types. This study also indicates that armadillos may be a fundamental prey for big cats, specially in Emas. However, armadillos may be overrepresented in this dietary study, owing to the high percentage of indigestible remains compared with other prey species.

B4.3. Methodological considerations

B4.3.1. Scat analysis

Dietary studies by faecal analysis have several shortcomings. First, it is not possible to distinguish between scavenging and predation. Jaguars and pumas may scavenge on large prey (Sunquist & Sunquist 2002) and in this study it is not possible to know if the cats actively selected a certain prey or if it was found already dead.

Number of analysed scats had a significant effect on percentage of biomass consumed of large and medium-sized prey reported in several studies, thus studies with fewer samples could be overestimating the importance of large prey in the jaguar diet because their sample size was not enough to detect a wider range of prey. Yet, standardized niche food breath was negatively affected by number of scats. If, like suggested by some authors, jaguars caught any prey they would encounter, it would be expected that collecting more scats would allow to detect more species in the diet, and diet would be more diverse (i.e. higher standardized food niche breath). However, collecting more samples probably allowed to evaluate more accurately which species are more important.

The number of scats is not the only consideration in describing and comparing diets, and attention must also be given to the diversity of sampled individuals (sexes and age classes), the size of the study area, and the times of year when scats are collected (Trites & Joy 2005). Although no data was yet available

from previous years or seasons in Cantão, special attention was given to the spatial distribution of the sampling effort, to ensure that the samples were the more diverse possible. In this study, as well in the reviewed articles, there was no reliable way of determining which individual jaguar left a given scat, and analyses may have been subject to pseudoreplication, with one individual contributing more heavily to results. For example, Ross *et al.* (1997) reported that food habits of solitary female cats can be significantly different from those of males. Hence, the diet composition may be biased towards individual preferences.

Nevertheless, scat analysis is easy to apply, allows large sample sizes and is non-intrusive and compatible with the welfare of jaguar, obvious advantages when compared with other alternatives (direct observation or stomach analysis).

B4.3.2. Predator identification method

Use of trained domestic dogs to find and identify carnivore scats is a recent method which application in this study has revealed very productive. Although sampling success between this study and the reviewed articles cannot be truly compared, due to differences in habitat, jaguar density, weather conditions, and because their samples were found opportunistically, 25 jaguar scats were obtained in this study in one month, while others have required 12-24 months to obtain between 23-228 scats by visual search by researchers.

Differentiating between jaguar and puma scats by identification of tracks found nearby has been commonly used in jaguar diet studies by faecal analysis (e.g. Rabinowitz & Nottingham 1986, Aranda & Sánchez-Cordero 1996, Núnez *et al.* 2000, Scognamillo *et al.* 2003). No significant effect of predator identification method (tracks versus laboratorial analysis) on any of the considered variables (diet components, standardized food niche breadth, percentage of consumed biomass of small, medium, and large prey) was found, suggesting that this is a reliable method, although its success will surely depend on habitat type, predator species, weather conditions, and researcher abilities. Alternatively, it could be the case that no effect was found because jaguars are the largest felid in Neotropics, and their scats would mainly be mistaken with those of pumas, which prey on a similar prey spectra.

B4.3.3. Diet composition estimation methods

The frequency of occurrence is the most adopted scat analysis method in carnivore diet studies, whilst the biomass method is considered to be the ecologically most relevant one (Gade-Jørgensen & Stagegaard 2000). However, more accurate estimation of consumed biomass would require knowledge of prey species weights for the specific study area, information which was not, and it is rarely, available.

In this study, as well in the reviewed articles, estimated consumed biomass may not be accurate because digestibility depends also on other factors, such as predator age, and variation of prey body size within species (Reynolds & Aebischer 1991). It has been recommended that it should be obtained by basing calculations on different values for the conversion factors (Reynolds & Aebischer 1991), but these are still scarce on the literature. The use of controlled feeding trials and calculation of a correction factor for scat analysis could thus be a valuable tool for gaining a more accurate estimate of jaguar diet in future studies.

B4.3.4. Prey abundance estimation by camera trapping

Several prey group were not possible to trap using cameras and a higher number of species which are available at both study areas were detected by camera trapping in Emas, most likely not only due to abundance differences, but also because of different habitat and camera placement, namely distance to roads (Srbek-Araujo & Chiarello 2005).

There is a controversy among camera-trapping researchers over the use of camera-trapping rates to assess densities of mammals that are not individually identifiable (Carbone *et al*. 2001, 2002; Jennelle *et al*. 2002). Nevertheless, a dietary analysis that accounted only for relative prey occurrence in the diet, would fail to detect possible selectivity by jaguars. It seems thus than the use of camera trapping data for prey abundance analysis, although faulty in some aspects, can even so give important information.

One main critique to this study is the fact that for its correct application, it would be required to calibrate the functional relationship by obtaining independent measures of the index and the animal density (Jennelle *et al.* 2002). Yet, using data from camera trapping jaguar might be considered a useful tool, specially because monitoring and obtaining reliable abundance estimates can be difficult and very costly, specially for cryptic large vertebrates that live in forested habitats (Carbone *et*

al. 2001) such as Cantão. Other advantage of this technique involves the accuracy of species determinations, specially when compared with other alternatives such as direct animal counts and track counts (Silveira *et al.* 2003).

B4.4. Implications for conservation

Brazil has the largest mammal diversity, with many species yet to be discovered. Furthermore, only a few sites have been adequately surveyed, and local lists are usually incomplete (Costa *et al.* 2005). The Amazon Basin, responsible for most of Brazil's biodiversity, sustains about 40% of the world's remaining tropical rainforests (Peres 2005), and has been identified as a fundamental jaguar conservation area (Sanderson *et al.* 2002). Studies on jaguar ecology in the Amazon have however remained almost not addressed. This study indicates that it can be difficult to predict which jaguar prey species are regionally important, a point that is critical to conservation strategies. It thus seems important to conduct similar assessments in other areas which are critical for the jaguar long-term survival. Although along their range jaguars have a generalist feeding behaviour, it does not mean that they could easily shift to other prey group, for example in case of habitat fragmentation, since they may be locally adapted to a certain prey spectra.

This study reported the use of livestock as prey by big cats, what indicates the importance of assessing prey use and selectivity in order to correctly manage natural prey populations. This is specially important because an efficient predator will accept all potential prey encountered when food is scarce or unpredictable (Polisar *et al.* 2003), being human persecution due to attacks on livestock one of the greatest threats to jaguar survival (Nowell & Jackson 1996).

Jaguar feeding ecology is particularly important because this endangered big cat is threatened by habitat fragmentation and overhunting in many areas. The Cerrado biodiversity hotspot is extremely threatened and the agricultural frontier is now moving into the Amazon Basin. Laurance *et al.* (2001) predicted that, given the habitat destruction and the planned road network for the Amazon, the next few decades will see a loss of 50% of the Amazonian forest. As natural habitats are becoming scarcer and smaller, special attention should be given to important prey items for jaguar conservation. Long-term monitoring projects, allowing dietary comparisons, could provided better-informed management decisions.

CONCLUSIONS

The overall goal in these research projects was to provide baseline information on human attitudes towards carnivores and carnivore feeding ecology. For the first project, specific objectives were to determine the attitudes trend in Portuguese high school students, and evaluate which factors most influence their attitudes, in order to better understand and minimize human-wildlife conflict. The second project aimed at determining prey use and selectivity by jaguars at Cantão State Park, and investigating which factors might affect jaguar diet variability along its geographical distribution.

Portuguese high school students had very positive attitudes towards carnivores and their conservation, but a general feeling of fear was found among them. Knowledge about carnivore species was generally low. The only significant differences found between study areas were a more positive perception of human-carnivore relationship in rural areas, and specially in southern urban areas. Source of information, interest about wildlife, frequency of close contact with nature and socio-demographic factors were the variables that best explained variation between students, and a positive correlation between knowledge and attitudes was detected. Contrary to what was expected, differences in proximity to carnivore distribution areas and rural environment are not main predictors of Portuguese students' attitudes towards carnivores. This study clearly shows that students' acceptance of carnivores is a complex phenomenon, depending not only on carnivore species, but also on a larger set of demographic and personal variables. Educational campaigns in Portuguese schools would be useful, to reinforce the general positive attitudes, and mainly to increase knowledge levels, and decrease self-reported fear of carnivores.

Jaguars in Cantão State Park, Brazil, preyed more frequently on opossums, peccaries and monkeys, whilst tapirs, peccaries, and cattle calves contributed the most for biomass consumed. Prey selectivity, based on information from camera trapping, indicated that jaguars might be positively selecting anteaters in this study area. This species shows a great diversity in feeding ecology, indicating that it can be difficult to predict which jaguar prey species are regionally important. Yet, habitat type and latitude seem to be important factors explaining jaguar diet variability. Jaguar feeding ecology is particularly important because, as natural habitats are becoming scarcer and smaller, special attention should be given to important prey

items. It is recommended that a long-term monitoring project, allowing dietary comparisons, should be implemented in the study area, because despite the importance of the Amazon Basin for jaguar conservation, studies on jaguar ecology in this area are still lacking.

These two research projects illustrate the importance of multidisciplinary studies in carnivore conservation, because the survival of these species depends not only of nature conservation and wildlife management, but also of acceptance by humans. Since without human tolerance from the different interest groups it will be difficult to achieve conservation and recovery of carnivore populations, long-term projects on carnivore ecology should implement human dimensions studies, whilst educational campaigns should be based on scientific data on species' ecology.

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Appendix 1.1
"Mammalian carnivores" Survey

This survey aims to analyse the knowledge and attitudes of the Portuguese student population regarding the conservation of terrestrial mammalian carnivores. Answers are confidential and will aid the scientific research in course. The survey will help understand the current attitudes of the target population and support environmental education projects related to Nature conservation awareness and practices.

PLEASE ANSWER ALL THE QUESTIONS.

I – The first group of questions aims to analyse the knowledge on Portuguese mammalian carnivores.

Read the next questions carefully and mark the correct answer with an X.

1. Which of the following characteristics is shown only by mammalian carnivores?
___ Diet based exclusively on meat.
___ Well developed canines and pre-molar teeth, designed to tear their preys.
___ Hair-covered body and production of milk from mammary glands for the nourishment of young.
___ To have parental care.
___ I don't know.

2. What role do carnivores play in the food chain?
___ Decomposers
___ Producers
___ Herbivores
___ Predators
___ I don't know.

3. When are carnivores generally more active?
___ During the morning
___ At midday
___ All day
___ During the night
___ I don't know.

4. What is the brown bear (*Ursus arctos*) status in Portugal?
___ We never had bears in Portugal
___ We still have bears roaming free in Portugal
___ They became extinct between the 17th and 19th centuries.
___ They became extinct in the 21th century.
___ I don't know.

5. The Iberian wolf (*Canis lupus signatus*) has the following geographical distribution in Portugal:
___ All over Portugal, excluding Açores and Madeira
___ Alentejo, Estremadura, Douro and Trás-os-Montes
___ Trás-os-Montes, Douro, Minho and Beira Interior
___ We do not have wolves in Portugal anymore.
___ I don't know.

6. How much does the average adult male Iberian wolf weigh?
___ Less than 10kg
___ 10-20 kg
___ 30-40kg
___ More than 50kg
___ I don't know.

7. What are the main wild preys of Iberian wolf?
___ Plants and insects
___ Wild ungulates (e.g.: roe deer, wild boar)
___ Livestock
___ Rodents and rabbits
___ I don't know.

8. How often is a wolf generally able to successfully kill wild prey?
___ In every case
___ 50%
___ 15%
___ 5%
___ I don't know.

9. What is the populational status of wolves in Portugal?
___ Generalized reduction
___ Stable in the north of Douro river
___ Increasing in the south of Douro river
___ Unknown
___ I don't know.

10. How many wolves are there in Portugal?
___ 50–60
___ 300–400
___ 600–700
___ 1000–1100
___ I don't know.

11. In the last 50 years, how many people were attacked by wolves in Portugal?
___ 0
___ 5
___ 15
___ 30
___ I don't know.

12. What is the main diet of the Iberian lynx (*Lynx pardinus*)?
___ Plants and insects
___ Wild and/or domestic ungulates
___ Rabbits and hares
___ Birds
___ I don't know.

13. Which of the following morphologic characteristics is **not** shown by the Iberian lynx?
___ Triangular ears with black tufts
___ Short tail
___ Spotted coat pattern
___ Size of an adult Iberian wolf
___ I don't know.

14. What is the populational status of Iberian lynx in Portugal?
___ Reduction
___ Stable
___ Increasing
___ Unknown
___ I don't know.

15. Which are the main threats affecting Iberian lynx?
___ Poaching and road accidents
___ Habitat destruction and prey availability
___ Human persecution and pollution
___ Diseases
___ I don't know.

16. What is the medium size of an Iberian lynx litter?
___ 2
___ 4
___ 8
___ 12
___ I don't know.

17. Which of the following characteristics allows to distinguish a wildcat (*Felis silvestris*) from a domestic cat?
___ Litter size
___ Size and fur characteristics
___ Gestation period
___ It is not possible to distinguish them by their characteristics.
___ I don't know.

18. Which is the main threatening factor for wildcats?
___ Habitat fragmentation
___ Human persecution
___ Hybridization (mating with domestic cats)
___ Wild prey disappearance
___ I don't know.

19. Which is an otter's (*Lutra lutra*) habitat?
___ Urban areas (e.g.: gardens)
___ Wetlands (e.g.: rivers)
___ Agricultural fields
___ Mountains
___ I don't know.

20. What is the main diet of badgers (*Meles meles*) in Portugal:
___ Plants and seeds
___ Rodents and rabbits
___ Fruits and insects
___ Fish and amphibians
___ I don't know.

21. Choose the badger's characteristic.
___ White belly and brown back
___ Tail with a striped pattern
___ Brown-reddish fur
___ Snout with two black lists
___ I don't know.

22. The genet (*Genetta genetta*) has the following geographical distribution in Portugal:
___ All over Portugal, excluding Açores and Madeira
___ Alentejo, Estremadura and Algarve
___ Trás-os-Montes, Douro, Minho and Beira Interior
___ The genet does not exist in Portugal.
___ I don't know.

23. How do you distinguish a weasel (*Mustela nivalis*) from a stoat (*Mustela erminea*)?
___ The stoat has a black-ended tail.
___ The stoat is smaller.
___ The weasel eats mainly mammals while the stoat eats mainly birds.
___ The stoat may get white fur during Winter.
___ I don't know.

24. What is the main diet of weasels?
___ Birds
___ Rabbits
___ Fish
___ Rodents
___ I don't know.

25. What is the medium size of a weasel litter?
___ 1-2
___ 4-6
___ 10-12
___ 15-20
___ I don't know.

26. Which of the following carnivores may be hunted in Portugal?
___ Weasel and stoat
___ Red fox and beech marten
___ Mongoose and red fox
___ Polecat e beech marten
___ I don't know.

27. When does a pine marten achieve sexual maturation?
___ 2-3 months
___ 5-6 months
___ 1-2 years
___ 4-5 years
___ I don't know.

28. Why was the American mink introduced in Europe?
___ For human consumption
___ To enrich European ecosystems' diversity
___ To commercialize their fur
___ To serve as other animals' prey
___ I don't know.

II – The second group of questions concerns your attitudes towards carnivores.

Read the next statements carefully and circle the answer that best corresponds to your opinion.

	I strongly disagree	I partially disagree	I don't know	I partially agree	I strongly agree
29. It is important to maintain carnivore populations in Portugal so that future generations can enjoy them.	1	2	3	4	5
30. Whether or not I get to see a wild carnivore, it is important for me that they exist.	1	2	3	4	5
31. Large carnivores produce high negative impacts in livestock.	5	4	3	2	1
32. I would be afraid of being alone in an area with large carnivores.	5	4	3	2	1
33. I would be afraid of being alone in an area with small/medium carnivores.	5	4	3	2	1
34. Carnivores steal preys from the hunters.	5	4	3	2	1
35. Carnivores cause pain to their preys only for pleasure.	5	4	3	2	1
36. Carnivores are key-elements in Nature.	1	2	3	4	5
37. It is unnecessary to have carnivores in Portugal because abundant populations already exist in other countries.	5	4	3	2	1
38. In areas where carnivores live in close proximity to humans, attacks on humans are common.	5	4	3	2	1
39. Carnivores' only function is to kill other animals.	5	4	3	2	1
40. Carnivores help maintain their preys' populations in equilibrium.	1	2	3	4	5
41. The presence of carnivores may favour tourism.	1	2	3	4	5
42. It should be allowed to hunt any carnivore.	5	4	3	2	1
43. Carnivore conservation is important.	1	2	3	4	5
44. More scientific research should be done to preserve carnivores.	1	2	3	4	5
45. We should preserve carnivores only for their beauty.	5	4	3	2	1
46. It is important to spread information on carnivores.	1	2	3	4	5
47. We should preserve carnivores because they have the right to live.	1	2	3	4	5

	I strongly disagree	I partially disagree	I don't know	I partially agree	I strongly agree
48. Carnivore conservation is important, as long as they do not disturb humans.	5	4	3	2	1
49. Carnivores are a threat to human populations.	5	4	3	2	1
50. Nature conservation is important.	1	2	3	4	5
51. I would like to obtain more information on carnivores.	1	2	3	4	5

III – **The third group of questions is related to your preferences concerning living beings.**

Circle the answer that best corresponds to your personal preference.

	I don't like them at all	I dislike them	Neutral	I like them	I like them a lot
52. Carnivores	1	2	3	4	5
53. Birds	1	2	3	4	5
54. Herbivores (e.g.: red deer)	1	2	3	4	5
55. Spiders	1	2	3	4	5
56. Fishes	1	2	3	4	5
57. Plants	1	2	3	4	5
58. Reptiles (e.g.: lizards)	1	2	3	4	5
59. Aquatic mammals	1	2	3	4	5
60. Amphibians (e.g.: frogs)	1	2	3	4	5
61. Rodents (e.g.: squirrel)	1	2	3	4	5
62. Bats	1	2	3	4	5
63. Insectivores (e.g.: shrew)	1	2	3	4	5

IV – The fourth group of questions is related to your personal experiences concerning carnivores and nature.

For each of the following species, choose the option that answers the question: do you know if this species exists freely in Portugal?

	I don't know this species	It doesn't exist	I don't think it exists	I think it exists	It exists
64. Stoat	1	2	3	4	5
65. Weasel	1	2	3	4	5
66. Beech marten	1	2	3	4	5
67. Wildcat	1	2	3	4	5
68. Genet	1	2	3	4	5
69. Wolverine	1	2	3	4	5
70. Iberian lynx	1	2	3	4	5
71. Iberian wolf	1	2	3	4	5
72. Otter	1	2	3	4	5
73. Mongoose	1	2	3	4	5
74. Pine marten	1	2	3	4	5
75. Red fox	1	2	3	4	5
76. Badger	1	2	3	4	5
77. Polecat	1	2	3	4	5
78. American mink	1	2	3	4	5

79. How often do you go to the field/forest?
___ Every day
___ At least once a week
___ Once a month
___ I rarely go

80. Choose the type of organization you belong to (**you may select several**):
___ Environmental non-governmental organization
___ Science club
___ Scouts
___ None of the above.

81. What has contributed to your knowledge of carnivores? (**CHOOSE 2**)
___ Folk stories, fairy-tales and legends
___ Movies
___ Nature films
___ Magazines and newspapers
___ Books
___ Biology lessons at school
___ Other

82. Has a carnivore ever caused you (or your family) any material/economical damages?
___ Yes
___ No
___ I don't know.

V – **Finally, this group of questions concerns personal information which will be kept confidential and anonymous.**

83. Sex :
___ Female
___ Male

84. Age: _____

85. Residence council: _____ and District: _____

86. Type of place of residence:
___ Village
___ Town
___ City

87. In what form do you prefer to obtain information? (**CHOOSE 3**)
___ Books
___ Articles in magazines and newspapers
___ Leaflets
___ Posters
___ Specialized activities
___ TV and radio
___ Internet
___ Lectures

Thank you for your co-operation!

Appendix 1.2.
Inquérito
"Mamíferos Carnívoros"

O objectivo deste inquérito é analisar os conhecimentos e atitudes da população estudantil Portuguesa em relação à conservação dos mamíferos terrestres carnívoros. As respostas são confidenciais e destinam-se a auxiliar a investigação científica em curso. As suas respostas ajudarão a compreender as actuais atitudes da população alvo deste inquérito, e servirão de base à definição de medidas de educação ambiental que visem melhorar as atitudes e práticas relacionadas com a Conservação da Natureza.

POR FAVOR, RESPONDA A TODAS AS QUESTÕES.

I – **O primeiro grupo de questões analisa o conhecimento acerca dos mamíferos carnívoros existentes em Portugal.**

Leia atentamente as seguintes perguntas e escolha a opção correcta, assinalando-a com X.

1. Qual das seguintes características é única dos mamíferos carnívoros?
___ Alimentarem-se exclusivamente de carne
___ Terem os dentes caninos e os pré-molares bem desenvolvidos e próprios para rasgarem as presas.
___ Terem o corpo coberto de pêlos e alimentarem os filhos com a secreção das glândulas mamárias.
___ Terem cuidados parentais
___ Não sei.

2. Que nível da cadeia alimentar ocupam os carnívoros?
___ Decompositores
___ Produtores
___ Herbívoros
___ Predadores
___ Não sei.

3. Geralmente, quando estão mais activos os carnívoros?
___ Durante a manhã
___ Ao meio-dia
___ Durante todo o dia
___ Durante a noite
___ Não sei.

4. Qual a situação do urso-castanho (*Ursus arctos*) em Portugal?
___ Nunca existiram ursos em Portugal
___ Ainda há ursos em liberdade em Portugal
___ Extinguiu-se entre o século XVII e o século XIX
___ Extinguiu-se no século XXI
___ Não sei.

5. O lobo-ibérico (*Canis lupus signatus*) apresenta a seguinte distribuição geográfica em território Português:
___ Todo o país, excluindo Açores e Madeira
___ Alentejo, Estremadura, Douro e Trás-os-Montes
___ Trás-os-Montes, Douro, Minho e Beira Interior
___ O lobo já não existe em Portugal
___ Não sei.

6. Em média, quanto pesa um lobo-ibérico macho adulto?
___ Menos de 10kg
___ 10-20 kg
___ 30-40kg
___ Mais de 50kg
___ Não sei.

7. Quais são as principais presas naturais do lobo-ibérico?
___ Plantas e insectos
___ Ungulados selvagens (ex: corço, javali)
___ Gado
___ Roedores e coelhos
___ Não sei

8. Aproximadamente, com que frequência conseguem os lobos capturar uma presa selvagem?
___ Sempre que tentam
___ 50% das vezes
___ 15% das vezes
___ 5% das vezes
___ Não sei.

9. Qual a tendência populacional do lobo-ibérico em Portugal?
___ Diminuição generalizada
___ Estável a norte do rio Douro
___ Aumento a sul do rio Douro
___ Desconhecida
___ Não sei

10. Quantos lobos existem em Portugal?
___ 50-60
___ 300-400
___ 600-700
___ 1000-1100
___ Não sei.

11. Nos últimos 50 anos, quantas pessoas foram atacadas por lobos em Portugal?
___ 0
___ 5
___ 15
___ 30
___ Não sei.

12. Qual o principal alimento do lince-ibérico (*Lynx pardinus*)?
___ Plantas e insectos
___ Ungulados selvagens e/ou domésticos
___ Coelhos e lebres
___ Aves
___ Não sei

13. Qual das seguintes características morfológicas **não** é apresentada pelo lince-ibérico?
___ Orelhas pontiagudas
___ Cauda curta
___ Padrão da pelagem com manchas
___ Tamanho de um lobo-ibérico adulto
___ Não sei.

14. Qual a tendência populacional actual do lince-ibérico em Portugal?
___ Diminuição
___ Estável
___ Aumento
___ Desconhecida
___ Não sei

15. Quais são os principais factores que ameaçam o lince-ibérico?
___ Caça ilegal e atropelamentos
___ Destruição do habitat e redução da quantidade de presas
___ Perseguição pelos seres humanos e poluição
___ Doenças
___ Não sei

16. Qual o tamanho médio de uma ninhada de lince-ibérico?
___ 2
___ 4
___ 8
___ 12
___ Não sei.

17. Qual das seguintes características distingue um gato-bravo (*Felis silvestris*) de um gato doméstico?
___ Número de crias
___ Tamanho e características da pelagem
___ Duração da gestação
___ Nenhuma, pois não se consegue distinguir
___ Não sei

18. Qual o principal factor que ameaça o gato-bravo?
___ Fragmentação do habitat
___ Perseguição pelos seres humanos
___ Hibridação (cruzamento com gato-doméstico)
___ Extermínio de presas selvagens
___ Não sei

19. Qual o habitat da lontra (*Lutra lutra*)?
___ Áreas urbanas (ex: jardins)
___ Zonas húmidas (ex: rios)
___ Campos agrícolas
___ Zonas montanhosas
___ Não sei

20. Quais os principais alimentos do texugo (*Meles meles*) em Portugal?
___ Plantas e sementes
___ Roedores e coelhos
___ Frutos e insectos
___ Peixes e anfíbios
___ Não sei

21. Indique a característica que se refere ao texugo.
___ Pelagem castanha no dorso e branca no ventre
___ Padrão da cauda com listas
___ Pelagem castanho-avermelhada
___ Focinho com duas listas negras
___ Não sei.

22. A geneta (*Genetta genetta*) apresenta a seguinte distribuição geográfica em território Português:
___ Todo o país, excluindo Açores e Madeira
___ Alentejo, Estremadura e Algarve
___ Trás-os-Montes, Douro, Minho e Beira Interior
___ A geneta não existe em Portugal
___ Não sei.

23. Como se distingue a doninha (*Mustela nivalis*) do arminho (*Mustela erminea*)?
___ O arminho tem a extremidade da cauda negra
___ O arminho é mais pequeno
___ A doninha come essencialmente mamíferos e o arminho come principalmente aves
___ O arminho pode adquirir uma pelagem branca no Inverno
___ Não sei

24. Qual o principal alimento da doninha?
___ Aves
___ Coelhos
___ Peixes
___ Roedores
___ Não sei

25. Qual o tamanho médio de uma ninhada de doninhas?
___ 1-2
___ 4-6
___ 10-12
___ 15-20
___ Não sei.

26. Quais dos seguintes carnívoros se podem caçar em Portugal?
___ Doninha e arminho
___ Raposa e fuinha
___ Saca-rabos e raposa
___ Toirão e fuinha
___ Não sei

27. Com que idade atinge a maturação sexual a fuinha?
___ 2-3 meses
___ 5-6 meses
___ 1-2 anos
___ 4-5 anos
___ Não sei.

28. Por que razão foi o visão-americano introduzido na Europa?
___ Para servir de alimento aos seres humanos
___ Para tornar mais diversos os ecossistemas Europeus
___ Para comercializar a sua pele
___ Para servir de alimento a outros animais
___ Não sei.

II – **O segundo grupo de questões relaciona-se com as suas atitudes relativamente aos mamíferos carnívoros.**

Leia atentamente as seguintes afirmações e escolha com um círculo a opção que melhor reflectir a sua opinião.

	Discordo totalmente	**Discordo parcialmente**	**Não sei**	**Concordo parcialmente**	**Concordo totalmente**
29. É importante conservar as populações de carnívoros em Portugal para que as próximas gerações possam desfrutar delas.	1	2	3	4	5
30. É importante que existam carnívoros em liberdade em Portugal, mesmo que eu nunca os veja.	1	2	3	4	5
31. Os grandes carnívoros causam um elevado impacto negativo na pecuária.	5	4	3	2	1
32. Eu teria medo de andar sozinha/o numa área onde eu soubesse que existiam grandes carnívoros.	5	4	3	2	1
33. Eu teria medo de andar sozinha/o numa área onde eu soubesse que existiam pequenos/médios carnívoros.	5	4	3	2	1
34. Os carnívoros roubam presas aos caçadores.	5	4	3	2	1
35. Os carnívoros causam sofrimento às suas presas apenas por prazer.	5	4	3	2	1
36.Os carnívoros são elementos fundamentais da Natureza.	1	2	3	4	5
37. Há muitos carnívoros noutros países, por isso não precisamos deles em Portugal.	5	4	3	2	1
38. Em áreas onde os carnívoros moram perto de pessoas, são comuns os ataques.	5	4	3	2	1
39. A única função dos carnívoros é matar outros animais.	5	4	3	2	1
40.Os carnívoros ajudam a manter o equilíbrio de populações das suas presas.	1	2	3	4	5
41. A presença de carnívoros pode aumentar o turismo.	1	2	3	4	5

	Discordo totalmente	Discordo parcialmente	Não sei	Concordo parcialmente	Concordo totalmente
42. Devia ser permitido caçar qualquer carnívoro.	5	4	3	2	1
43. A conservação dos carnívoros é importante.	1	2	3	4	5
44. Devia haver mais investigação científica para conservar os carnívoros.	1	2	3	4	5
45. Devemos conservar os carnívoros apenas pela sua beleza.	5	4	3	2	1
46. É importante fornecer informação sobre carnívoros.	1	2	3	4	5
47.Devemos conservar os carnívoros porque eles têm direito a viver.	1	2	3	4	5
48. A conservação de carnívoros é importante, desde que estes não incomodem os seres humanos.	5	4	3	2	1
49. Os carnívoros são uma ameaça para as populações humanas.	5	4	3	2	1
50. A conservação da Natureza é importante	1	2	3	4	5
51. Eu gostaria de receber mais informação sobre carnívoros	1	2	3	4	5

III – **O terceiro grupo de questões relaciona-se com as suas preferências relativamente aos seres vivos.**

Leia atentamente as seguintes afirmações e escolha com um círculo a opção que melhor reflectir os seus gostos pessoais.

	Não gosto	Gosto pouco	Tanto me faz	Gosto	Gosto muito
52. Mamíferos carnívoros	1	2	3	4	5
53. Aves	1	2	3	4	5
54. Herbívoros (ex: veado)	1	2	3	4	5
55. Aranhas	1	2	3	4	5
56. Peixes	1	2	3	4	5
57. Plantas	1	2	3	4	5
58. Répteis (ex: lagartos)	1	2	3	4	5
59. Mamíferos aquáticos	1	2	3	4	5
60. Anfíbios (ex: rãs)	1	2	3	4	5
61. Roedores (ex: esquilo)	1	2	3	4	5
62. Morcegos	1	2	3	4	5
63. Insectívoros (ex: musaranho)	1	2	3	4	5

IV – O quarto grupo de questões relaciona-se com as suas experiências pessoais relativamente aos mamíferos carnívoros e natureza.

Para cada uma das seguintes espécies, escolha a opção que mais se adequa à questão: sabe se existe esta espécie no meio natural em Portugal?

	Não conheço esta espécie	Não existe	Acho que não existe	Acho que existe	Sim, existe
64. Arminho	1	2	3	4	5
65. Doninha	1	2	3	4	5
66. Fuinha	1	2	3	4	5
67. Gato-bravo	1	2	3	4	5
68. Geneta	1	2	3	4	5
69. Glutão	1	2	3	4	5
70. Lince-ibérico	1	2	3	4	5
71. Lobo-ibérico	1	2	3	4	5
72. Lontra	1	2	3	4	5
73. Saca-rabos	1	2	3	4	5
74. Marta	1	2	3	4	5
75. Raposa	1	2	3	4	5
76. Texugo	1	2	3	4	5
77. Toirão	1	2	3	4	5
78.Visão-americano	1	2	3	4	5

79. Com que frequência costuma estar no campo/floresta?
___ Todos os dias
___ Pelo menos uma vez por semana
___ Uma vez por mês
___ Raramente

80. Indique o tipo de organização a que pertence (**podem ser seleccionadas várias**):
___ Organização Ambiental Não-Governamental
___ Clube de Ciências
___ Escuteiros
___ Nenhum destes grupos.

81. Onde considera ter recebido o seu conhecimento acerca de mamíferos carnívoros? (**ESCOLHA 2**)
___ Histórias tradicionais, lendas e histórias de encantar
___ Filmes
___ Documentários da Natureza
___ Revistas e jornais
___ Livros
___ Aulas de Ciências na escola
___ Outro

82. Algum carnívoro selvagem lhe causou (ou à sua família) prejuízos materiais/económicos?
___ Sim
___ Não
___ Não sei.

V – **Por último, este grupo de questões relaciona-se com dados pessoais que serão mantidos confidenciais e são anónimos.**

83. Sexo :
___ Feminino
___ Masculino

84. Idade: _____

85. Concelho _____ e Distrito _____ de residência

86. Tipo de localidade onde mora:
___ Aldeia
___ Vila
___ Cidade

87. Quais as fontes de informação que prefere? (**ESCOLHA 3**)
___ Livros
___ Revistas e jornais
___ Panfletos
___ Posters
___ Actividades especialmente organizadas para divulgação do tema
___ TV e rádio
___ Internet
___ Aulas

Muito obrigada pela sua participação!

Appendix 1.3. Percentage of students who answered correctly each knowledge question per study area. Total number of students is given within brackets.

Question	A1 (n=170)	A2 (n=92)	B1 (n=98)	B2(n=117)	C1(n=104)	C2(n=169)	D1(n=89)	D2(n=130)
1	52	60	45	37	50	45	44	47
2	92	97	97	91	97	96	96	94
3	22	23	23	28	38	31	40	30
4	21	11	33	21	30	17	18	26
5	58	52	46	43	57	50	50	43
6	46	46	46	44	43	50	43	46
7	24	23	24	21	31	27	21	23
8	2	4	1	2	3	4	6	2
9	5	8	8	9	3	5	6	8
10	19	16	17	20	23	21	22	18
11	6	11	8	13	16	15	15	15
12	72	74	68	72	63	71	75	73
13	39	37	26	30	43	50	43	38
14	75	82	72	62	76	72	73	75
15	64	71	67	61	67	60	70	67
16	16	24	16	22	17	27	15	18
17	66	64	63	52	78	74	66	61
18	26	24	36	30	22	20	17	18
19	84	87	89	86	91	92	89	86
20	17	14	27	25	32	23	24	26
21	25	23	20	26	28	13	24	28
22	3	2	2	1	3	2	1	2
23	5	2	1	5	3	4	3	3
24	4	6	5	5	6	5	5	5
25	46	45	43	48	47	37	37	41
26	8	12	17	20	33	45	21	17
27	14	13	18	20	14	11	17	16
28	19	16	19	24	11	13	19	13
64	29	28	20	27	42	27	30	34
65	95	93	93	81	92	87	89	89
66	70	62	80	62	76	70	74	68
67	88	80	84	81	89	90	87	81
68	16	16	17	21	36	29	24	24
70	81	89	85	79	79	82	87	81
71	89	92	91	85	86	85	89	85
72	76	78	81	72	78	75	82	79
73	19	16	14	17	78	78	34	73
74	24	15	44	25	39	37	45	44
75	98	100	98	94	97	96	98	96
76	89	91	94	77	91	86	87	91
77	24	14	19	24	37	36	28	18
78	25	14	21	25	26	27	25	24

Appendix 1.4. Percentage of students' answers to each attitudinal question by scale category [a]. Total number of students = 969.

Questions	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
29. It is important to maintain carnivore populations in Portugal so that future generations can enjoy them.	2	7	3	35	53
30. Whether or not I get to see a wild carnivore, it is important for me that they exist.	3	6	9	36	46
31. Large carnivores produce high negative impacts in livestock.	15	27	28	22	6
32. I would be afraid of being alone in an area with large carnivores.	7	13	14	27	38
33. I would be afraid of being alone in an area with small/medium carnivores.	21	26	12	26	14
34. Carnivores steal preys from the hunters.	21	21	19	27	11
35. Carnivores cause pain to their preys only for pleasure.	65	16	11	6	2
36. Carnivores are key-elements in Nature.	2	3	6	12	65
37. It is unnecessary to have carnivores in Portugal because abundant populations already exist in other countries.	76	14	5	2	2
38. In areas where carnivores live in close proximity to humans, attacks on humans are common.	11	26	29	26	7
39. Carnivores' only function is to kill other animals.	54	28	7	7	3
40. Carnivores help maintain their preys' populations in equilibrium.	3	5	21	29	41
41. The presence of carnivores may favour tourism.	6	10	23	39	21
42. It should be allowed to hunt any carnivore.	65	22	5	3	3
43. Carnivore conservation is important.	1	2	5	25	67
44. More scientific research should be done to preserve carnivores.	1	1	8	29	60
45. We should preserve carnivores only for their beauty.	54	34	4	7	1
46. It is important to spread information on carnivores.	1	2	4	28	65
47. We should preserve carnivores because they have the right to live.	1	1	2	25	69
48. Carnivore conservation is important, as long as they do not disturb humans.	14	25	6	30	24
49. Carnivores are a threat to human populations.	33	38	10	15	3
50. Nature conservation is important.	1	1	2	4	92
51. I would like to obtain more information on carnivores.	2	3	9	35	51

[a] When sum is not 100%, the rest of the students did not answer the question.

REFERENCES

Ackerman, B. B.; Lindzey, F. G.; Hemker, T. P. (1984). Cougar food habits in southern Utah. J*ournal of Wildlife Management*, 48: 147-155.

Álvares, F.; Pereira, E.; Petrucci-Fonseca, F. (2000). O lobo no Parque Internacional Gerês-Xurés. Situação populacional, aspectos ecológicos e perspectivas de conservação. *Galemys*, 12: 223-239. [In Portuguese with English abstract].

Álvares, F.; Primavera, P. (2004). The wolf in rural communities' culture in the north of Portugal. *Wolfprint*, 20: 10-12.

Andersone, Z.; Ozolins, J. (2002). *Investigation of public opinion about three large carnivore species in Latvia – brown bear* (Ursus arctos)*, wolf* (Canis lupus) *and lynx* (Lynx lynx). WWF Latvia. [0nline]. [Acessed 27th September 2006]. Available from: http://www.lcie.org/Docs/HD/Andersone%20WWF%20Latvian%20attitudes.pdf

Andersone, Z.; Ozolins, J. (2004). Public perception of large carnivores in Latvia. *Ursus,* 15: 181-187.

Aranda, M.; Sánchez-Cordero, V. (1996). Prey spectra of jaguar *(Panthera onca)* and puma (*Puma concolor)* in tropical forests of Mexico. *Studies on Neotropical Fauna and Environment,* 31: 65-67.

Arizona Game and Fish Department (2006). *Proceedings from Mexico Workshop on Jaguar Conservation and Management.* [Online].[Acessed 20th April 2007]. Available from: http://www.azgfd.gov/w_c/es/documents/2006.pdf .

Baayen, R.H.; Davidson, D.J.; Bates, D.M. (2007). *Mixed-effects modeling with crossed random effects for subjects and items*. Manuscript submitted for publication. [Online]. [Acessed 30th May 2007]. Available from: http://www.mpi.nl/world/persons/private/baayen/publications/baayenDavidsonBates.pdf.

Baker, S. E.; Macdonald, D. W. (2000). Foxes and foxhunting on farms in Wiltshire: A case study. *Journal of Rural Studies,* 16: 185-201.

Bath, A. (1989). The public and wolf reintroduction in Yellowstone National Park. *Society and Natural Resources,* 2: 297-306.

Bath, A. (1991). Identification and documentation of public attitudes toward wolf reintroduction in Yellowstone National Park. *In*: Varley, J.D; Brewster, W. (eds.), *Wolves for Yellowstone? A Report to the United States Congress*. National Park Service, Yellowstone National Park, Wyoming.

Bath, A. (1994). Public attitudes toward polar bears: An application of human dimensions in wildlife resources research. *In*: Thompson, I. (ed). *Proceedings of International Union of Game Biologists' XXI Congress*, Volume 1. Canadian Forest Service, Halifax, Nova Scotia, Canada, pp 168–174.

Bath, A. (2000). *Human dimensions in wolf management in Savoie and Des Alps Maritimes, France*. France LIFE-Nature project Le Retour du Loup dans les Alps Françaises. 150 pp.

Bath, A.; Buchanan, T. (1989). Attitudes of interest groups in Wyoming toward wolf restoration in Yellowstone National Park. *Wildlife Society Bulletin*, 17: 519–525.

Bath, A.; Farmer, L. (2000). *Europe's carnivores: a survey of children's attitudes toward wolves, bears and otters.* World Wildlife Fund, Godalming, United Kingdom.

Bath, A.; Majić, A. (2001). *Human dimensions in wolf management in Croatia: understanding attitudes and beliefs of residents in Gorski kotar, Lika and Dalmatia towards wolves and wolf management.* [0nline]. [Acessed 27th September 2006]. Available from: http://www.lcie.org/Docs/HD/LCIE%20Bath%20Croatia%20wolf%20HD%203.pdf

Berger, J. (1999). Anthropogenic extinction of top carnivores and interspecific animal behaviour: implications of the rapid decoupling of a web involving wolves, bears, moose and ravens. *Proceedings Biological Sciences*. 266 (1435): 2261-2267.

Bessa-Gomes, C.; Fernandes, M.; Abreu, P.; Castro, L.; Ceia, H.; Pinto, B.; Pires, A.E. (2002). Le lynx pardelle (*Lynx pardinus*) au Portugal: diverses approches dans un scénario de pré-extinction. *In:* Chapron, G. & Moutou, F. (eds) *L'étude et la conservation des carnivores*. Societé Française par L'étude et la Protection de Mammiféres, Paris, pp 128-136. [In French].

Bonesi, L.; Palazón, S. (2007). The american mink in Europe: status, impacts and control. *Biological Conservation,* 134: 470-483.

Borralho, R.; Rego, F.; Palomares, F.; Hora, A. (1996). The distribution of the Egyptian Mongoose *Herpestes ichneumon* (L.) in Portugal. *Mammal Review,* 25(4): 229-236.

Bowman, J.L.; Leopold, B.D.; Vilella, F.J.; Gill, D.A.; Jacobson, H.A. (2001). Attitudes of landowners toward American black bears compared between areas of high and low bear populations. *Ursus,* 12: 153-160.

Bright, A.D.; Manfredo, M.J. (1995). The quality of attitudinal information regarding natural resource issues: the role of attitude strength, importance, and information. *Society and Natural Resources,* 8: 399–414.

Cabral, M. J.; Almeida, J.; Almeida, P. R.; Dellinger, T,; Ferrand de Almeida, N.; Oliveira, M.E.; Palmeirim, J. M.; Queiroz, A. I.; Rogado, L.; Santos-Reis, M. (2005). *Livro Vermelho dos Vertebrados de Portugal. Peixes Dulciaquícolas e Migradores, Anfíbios, Répteis, Aves e Mamíferos.* Instituto da Conservação da Natureza, Lisboa. 660pp. [In Portuguese].

Carbone, C.; Christie, S.; Coulson, T.; Franklin, N.; Ginsberg, J. R.; Griffiths, M.; Holden, J.; Kinnaird, M.; Laidlaw, R.; Lynam, A.; Macdonald, D. W.; Martyr, D.; McDougal, C.; Nath, L.; O'Brien, T.; Seidensticker, J.; Smith, D. J. L.; Tilson, R.; Wan Shahruddin, W. (2002). The use of photographic rates to estimate densities of cryptic mammals: a response to Jennelle *et al*. *Animal Conservation,* 5: 121-123.

Carbone, C.; Coulson, T.; Christie, S.; Conforti, K.; Seidensticker, J.; Franklin, N.; Tilson, R.; Ginsberg, J. R.; Kinnaird, M.; Laidlaw, R.; Lynam, A.; O'Brien, T.; Wan Shahruddin, W. N.; Griffiths, M.; Holden, J.; Martyr, D.; Kawanishi, K.; Sunquist, M.; Macdonald, D. W.; Nath, L.; McDougal, C.; Smith, D. J. L. (2001). The use of photographic rates to estimate densities of tigers and other cryptic mammals. *Animal Conservation,* 4: 75-79.

Cardillo, M.; Purvis, A.; Sechrest, W.; Gittleman, J. L.; Bielby, J. (2004). Human population density and extinction risk in the world's carnivores. *PLoS Biol*, 2(7): e197.

Caro T.; Stoner C. (2003). The potential for interspecific competition among African carnivores. *Biological Conservation,* 110 (1): 67-75.

Ceia, H.; Abreu, P.; Castro, L.R.; Fernandes, M. (1998). *Lince-ibérico em Portugal. Bases para a sua Conservação.* Relatório Técnico, ICN/LIFE, Lisboa, 191 pp. [In Portuguese].

Ciucci, P.; Boitani, L.; Pelliccioni, E. R.; Rocco, M.; Guy, I. (1996). A comparison of scat-analysis methods to assess the diet of the wolf *Canis lupus. Wildlife Biology*, 2: 37-48.

Collevatti, R. G. ; Leite, K. C. E. ; Miranda, G. H. B.; Rodrigues,, F. H. G. (2007) . Evidences of high inbreeding in a population of the endangered giant anteater, *Myrmecophaga tridactyla* (Myrmecophagidae), from Emas National Park, Brazil. *Genetics and Molecular Biology,* 30: 112-120.

Colwell, R. R.; Futuyma, D. J. (1971). On the measurement of niche breadth and overlap. *Ecology,* 52: 473-572.

Coolican, H. (2004). *Research Methods & Statistics in Psychology*. 4th Edition. Hodder & Stoughton Educational, U.K.

Costa, L.P.; Leite, Y.L.R.; Mendes, S.L.; Ditchfield, A.D. (2005). Mammal conservation in Brazil. *Conservation Biology*, 19(3):672-679.

Crawley, M.J. (2005). *Statistics: an introduction using R.* John Wiley and Sons, New York, USA. 327 pp.

Crawshaw Jr, P. G.; Quigley, H. B. (1991). Jaguar spacing, activity and habitat use in a seasonally flooded environment in Brazil. *Journal of Zoology,* 223: 357-370.

Crawshaw, P. G. (1995). Comparative ecology of ocelot and jaguar in a protected subtropical forest in Brazil and Argentina. Doctoral thesis. University of Florida, USA.

Day M.F. (1966). Identification of hair and feather fragments in the guts and faeces of stoats and weasels. *Journal of Zoology,* 148: 1-217.

Decker, D. J.; Brown, T. L.; Siemer, W. F. (2001). Evolution of people-wildlife relations. *In*: Decker, D. J.; Brown, T. L.; Siemer, W. F. (eds). *Human dimensions of wildlife management in North America.*. The Wildlife Society, Bethesda, pp. 3-22.

Delibes, M.; Hiraldo, F. (1981). The rabbit as a prey in the Iberian Mediterranean ecosystem. *In*: Meyers, K.;MacInnes, C.D. (eds), *Proceedings of the World Lagomorph Conference (1979)*, University of Guelph, Ontario, pp. 654-663.

Delibes, M.; Rodríguez, A.; Ferreras, P. (2000). *Action plan for the conservation of the Iberian lynx in Europe (*Lynx pardinus*)*. Council of Europe Publishing, Strasbourg.

DeRosa, B. (1984). Research Review: Differences between boys' and girls' attitudes toward animals. *Humane Education*, 8(3): 22.

Diamond, J. (1993). New Guineans and their natural world. *In* Kellert, S.R.; Wilson, E.O. (eds.), *The biophilia hypothesis*. Washington, D.C.: Island Press, pp. 251–271.

Dobson, M. (1998). Mammal distributions in the western Mediterranean: the role of human intervention. *Mammal Rev.* 28: 77-88.

Dupré, E.; Genovesi, P.; Pedrotti, L. (1998). *Studio di fattibilità per la reintroduzione dell orso bruno* (Ursus arctos) *sulle Alpi Centrali*. Istituto Nationale per la Fauna Selvatica and Parco Adamello Brenta, Bologna, Italy [In Italian].

Emmons, L. (1997). *Neotropical Rainforest Mammals*. University of Chicago Press, Chicago.

Emmons, L. H. (1987). Comparative feeding ecology of felids in a neotropical rainforest. *Behav. Ecol. Sociobiol.* 20: 271–283.

Espirito-Santo, C.; Petrucci-Fonseca, F. (2004). Human dimensions in Iberian wolf Management in Portugal. *WolfPrint*, 20: 7-9.

Farrell, L. E.; Roman, J.; Sunquist, M. E. (2000). Dietary separation of sympatric carnivores identified by molecular analysis of scats. *Molecular Ecology,* 9: 1583-1590.

Fink, Arlene. (2006). *How to Conduct Surveys: A Step-by-Step Guide*. 3rd Edition. Sage. 110 pp.

Fox, J. (2002). *Mixed-Effects Models on-line appendix, An R and S-PLUS Companion to Applied Regression*. [Online]. [Acessed 30th May 2007] Available from: http://socserv.mcmaster.ca/jfox/Books/Companion/appendix-mixed-models.pdf.

Fuller, T. K.; Sievert, P.R.. (2001). Carnivore demography and the consequences of changes in prey availability. In: Macdonald, D., Gittleman, J., Wayne, R., Funk, S. (eds.), *Conservation of Carnivores.* Cambridge University Press, Cambridge, pp. 163-178.

Gade-Jorgensen, I.; Stagegaard, R. (2000). Diet composition of wolves Canis lupus in east-central Finland. *Acta Theriologica,* 45: 537-547.

Gangas, K.E. (2004). Can attitudes toward wolves change from fear to curiosity? Experiences from an educational program in Norway. *International Wolf*, 14(3): 12.

Garla, R. C.; Setz, E. Z. F.; Gobbi, N. (2001). Jaguar (*Panthera onca*) food habits in atlantic rain forest of Southeastern Brazil. *Biotropica,* 33: 691-696.

Gompper, M. E.; Gittleman, J. L. (1991). Home range scaling: intraspecific and comparative trends. *Oecologia,* 87: 343-348.

González, C. A.; Miller, B. J. (2002). Do jaguars (*Panthera onca*) depend on large prey?. *Western North American Naturalist,* 62: 218-222.

Goszczyński J. (1974). Studies on the food of foxes. *Acta Theriologica*, 19: 1-18.

Gray, G.G. (1993). *Wildlife and People: The Human Dimensions of Wildlife Ecology*. Chicago, The University of Illinois Press.

Hair, J.F.; Anderson, R. E.; Tathan, R. L.; Black, W.C. (1998). *Multivariate Data Analysis.* 5th ed. New Jersey, Prentice Hall.

Harrison, R.L. (2006). A comparison of survey methods for detecting bobcats. *Wildlife Society Bulletin*, 34: 548-552.

Hayward, M. W.; Henschel, P.; O'Brien, J.; Hofmeyr, M.; Balme, G.; Kerley, G. I. H. (2006a). Prey preferences of the leopard *(Panthera pardus)*. *Journal of Zoology,* 270: 298-313.

Hayward, M. W.; Hofmeyr, M.; O'Brien, J.; Kerley, G. I. H. (2006b). Prey preferences of the cheetah *(Acinonyx jubatus)* (Felidae: Carnivora): morphological limitations or the need to capture rapidly consumable prey before kleptoparasites arrive?. *Journal of Zoology,* 270: 615-627.

Hungerford, H.R.; Volk, T. (1990). Changing learner behavior through environmental education. *Journal of Environmental Education*. 21(3): 8-21.

INE (2002). *Resultados definitivos Censos 2001*. [Online]. [Acessed 30th May 2007]. Available from: http://www.ine.pt/censos2001/.

Iriarte, J. A.; Franklin, W. L.; Johnson, W. E.; Redford, K. H. (1990). Biogeographic variation of food habits and body size of the America puma. *Oecologia,* 85: 185-190.

IUCN (2006). *2006 IUCN Red List of Threatened Species.* [Online]. [Acessed 30th May 2007]. Available from: www.iucnredlist.org.

Jácomo, A. T.; Silveira, L.; Diniz Filho, J. A. F. (2004). Niche separation between the maned wolf *(Chrysocyon brachyurus)*, the crab-eating fox *(Dusicyon thous)* and the hoary fox *(Dusicyon vetulus)* in central Brazil. *Journal of Zoology,* 262: 99-106.

Jamieson, S. (2004). Likert scales: how to (ab)use them. *Medical Education*, 38(12): 1217-1218.

JCF (2006). *Programa de monitoramento da população de onça-pintada do Parque Estadual do Cantão e entorno – Relatório parcial.* Jaguar Conservation Fund. 21 pp. [In Portuguese].

Jennelle, C. S.; Runge, M. C.; MacKenzie, D. I. (2002). The use of photographic rates to estimate densities of tigers and other cryptic mammals: a comment on misleading conclusions. *Animal Conservation,* 5: 119–120.

Johnson, A., Vongkhamheng, C., Hedemark, M. , Saithongdam, T. (2006). Effects of human-carnivore conflict on tiger *(Panthera tigris)* and prey populations in Lao PDR. *Animal Conservation,* 9: 421-430.

Kaczensky, P. (2003). Is coexistence possible? Public opinion of large carnivores in the Alps and Dinaric Mountains. *In*: Krystufek, B.; Flajsman, B.; Griffiths, H.I. (eds*.), Living With Bears. A Large Carnivore in a Shrinking World.* Ecological Forum of the Liberal Democracy of Slovenia, Ljubljana, Slovenia, pp. 59–89.

Kaczensky, P.; Gossow, H.; Blazic, M. (2004). Public attitudes towards brown bears (*Ursus arctos*) in Slovenia. *Biological Conservation,* 118: 661-674.

Kaiser, H.F. (1958). The varimax criterion for analytic rotation in factor analysis. *Psychometrika,* 23: 187-200.

Kaltenborn, B. P.; Bjerke, T. (2002). The relationship of general life values to attitudes toward large carnivores. *Human Ecology Review,* 9(1): 55-61.

Kanzaki, N.; Maruyama, N.; Inoue, T. (1996). Japanese attitudes towards wolves and its recovery. *Journal of Wildlife Research,* 1: 268–271.

Karanth, K. U.; Sunquist, M. E. (1995). Prey selection by tiger, leopard and dhole in tropical forests. *Journal of Animal Ecology,* 64: 439-450.

Karlsson, J. (2007). *Management of wolf and lynx conflicts with human interests*. Doctoral diss. Dept. of Ecology, SLU. Acta Universitatis agriculturae Sueciae vol. 2007:59.

Kellert, S.R. (1985). Attitudes toward animals. Age-related development among children. *Journal of Environmental Education*, 16 (3): 29-39.

Kellert, S.R. (1994). Public attitudes toward bears and their conservation. *International Conference on Bear Research and Management,* 9: 43-50.

Kellert, S.R.; Black, M.; Rush, C.R.; Bath, A.J. (1996). Human culture and large carnivore conservation in North America. *Conservation Biology,* 10: 977–990.

Khan, M. (2004). *Ecology and conservation of the Bengal tiger in the Sundarbans mangrove forest of Bangladesh.* Doctoral thesis. University of Cambridge, UK. 336pp.

Kleiven, J.; Bjerke, T.; Kaltenborn, B. P. (2004). Factors influencing the social acceptability of large carnivore behaviours. *Biodiversity and Conservation,* 13: 1647-1658.

Kruuk, H. (2002). *Hunter and Hunted: Relationships Between Carnivores and People*. Cambridge University Press, Cambridge, UK.

Laurance, W. F.; Cochrane, M. A.; Bergen, S.; Fernside, P. M.; Delamonica, P.; Barber C.; D'Angelo, S.; Fernandes. T. (2001). The future of the Brazilian Amazon. *Science's Compass Policy Forum, 19 January*, 291:438-439.

Likert, R. (1932). A Technique for the Measurement of Attitudes. *Archives of Psychology,* 140: 44-53.

Lindsey, P. A.; Du Toit, J. T.; Mills, M. G. L. (2005). Attitudes of ranchers towards African wild dogs Lycaon pictus: Conservation implications on private land. *Biological Conservation,* 125: 113-121.

Livet, F; Roeder, J.J. (1987). *La genette (*Genetta genetta *Linnaeus, 1758)*. Encyclopédie dês Carnivores de France, nº 16, Societé Française pour l'Étude et la Protection des Mammifères, 33 pp. [In French].

Lockie, J.D. (1959). The estimation of the food of foxes. *Journal of Wildlife Management,* 23: 224-227.

Lohr, C.; Ballard, W. B.; Bath, A. (1996). Attitudes toward gray wolf reintroduction to New Brunswick. *Wildlife Society Bulletin,* 24: 414-420.

MADRP (2006). *Plano estratégico nacional 2007-2013 – Desenvolvimento rural.* Ministério da Agricultura, do Desenvolvimento Rural e das Pescas, Lisboa. [In Portuguese].

Manly, B. F. J. (1997). *Randomization, Bootstrap and Monte Carlo Methods in Biology*. Chapman & Hall, London.

Marker, L.L.; Mills, M.G.L.; Macdonald, D.W. (2003). Factors influencing perceptions of conflict and tolerance toward cheetahs on Namibian farmlands. *Conservation Biology*, 17: 1290–1298.

Mathias, M. L.; Ramalhinho, M. G.; Santos-Reis, M.; Petrucci-Fonseca, F.; Libois, R.; Fons, R.; Ferraz de Carvalho, G.; Oom, M. M.; Collares-Pereira, M. (1998b). The terrestrial mammals from the Azores islands: an updated overview. *Mammalia*, 62(3): 397-407

Mathias, M.L.; Santos-Reis, M.; Palmeirim, J.; Ramalhinho, M.G. (1998a). *Mamíferos de Portugal.* Edições INAPA, Lisboa, Portugal, 145 pp. [In Portuguese].

Matos, H.; Santos-Reis, M. (2006). Distribution and status of the pine marten *Martes martes* in Portugal. *In:* Santos-Reis, M.; Birks, J.D.S.; O'Doherty, E.C.; Proulx, G. (eds). *Martes in Carnivore Communities.* Alpha Wildlife Research & Management Ltd., Alberta, Canada, pp. 47-61.

Mech, L. D.; Smith, D. W.; Murphy, K. M.; MacNulty, D. R. (2001). Winter severity and wolf predation on a formerly wolf-free elk herd. *Journal of Wildlife Management,* 65: 998-1003.

Mech, L.D. (1995). The challenge and opportunity of recovering wolf populations. *Conservation Biology,* 9: 270–278.

Meulman, J. J.; Heiser, W. J. (2004). *SPSS Categories 13.0.* SPSS Inc., Chicago, USA. 372 pp.

Meulman, J.J.; van der Kooij, A.J.; Babinec, A. (2002). New features of categorical principal component analysis for complicated data including data mining. *In*: Gaul, W.; Ritter, G. (eds). *Classification, Automation and New Media.* Springer, Berlin, pp. 207–217.

Michalski, F.; Boulhosa, R.L.P.; Faria, A.; Peres, C.A. (2006). Human-wildlife conflicts in a fragmented Amazonian forest landscape: Determinants of large felid depredation on livestock. *Animal Conservation,* 9: 179-188.

Mishra, C.; Allen, P.; McCarthy, T.; Madhusudan, M.D.; Bayarjargal, A.; Prins, H.H.T. (2003). The role of incentive programs in conserving the snow leopard. *Conservation Biology*, 17: 1512–1520.

Naughton-Treves, L.; Grossberg, R.; Treves, A. (2003). Paying for tolerance: rural citizen's attitudes toward wolf depredation and compensation. *Conservation Biology*, 17(6): 1500-1511.

Novack, A.J.; Main, M.B.; Sunquist, M.E.; Labisky, R.F. (2005). Foraging ecology of jaguar (*Panthera onca*) and puma (*Puma concolor*) in hunted and non-hunted sites within the Maya Biosphere Reserve, Guatemala. *Journal of Zoology,* 267: 167-178.

Nowell, K.; Jackson, P. (1996). *Wild Cats Status Survey and Conservation*. Switzerland: IUNCN.

Núñez, R.; Miller, B.; Lindzey, F. (2000). Food habits of jaguars and pumas in Jalisco, Mexico. *Journal of Zoology*, 252: 373-379.

O'Brien, T. G.; Kinnaird, M. F.; Wibisono, H. T. (2003). Crouching tigers, hidden prey: Sumatran tiger and prey populations in a tropical forest landscape. *Animal Conservation,* 6: 131-139.

Ogada, M.O.; Woodroffe, R.; Oguge, N.O.; Frank, L.G. (2003). Limiting depredation by African carnivores: the role of livestock husbandry. *Conservation Biology*, 17: 1521–1530.

Oli, M.K.; Taylor, I.R.; Rogers, M.E. (1994). Snow leopard *Panthera uncia* predation of livestock: an assessment of local perceptions in the Annapurna conservation area, Nepal. *Biological Conservation,* 68: 63–68.

Packer, J. J.; Birks, J. D. S. (1999). An assessment of British fanners' and gamekeepers' experiences, attitudes and practices in relation to the European polecat *Mustela putorius. Mammal Review,* 29: 75-92.

Peres, C.A. (2005). Why we need mega-reserves in Amazonian forests. *Conservation Biology,* 19: 728-733.

Petrucci-Fonseca, F. (1990). *O lobo* (Canis lupus signatus *Cabrera, 1907) em Portugal. Problemática da sua Conservação.* PhD. Thesis, University of Lisbon, Portugal, 392 pp [In Portuguese].

Pianka, E. R. (1966). Convexity, desert lizards, and spatial heterogeneity. *Ecology*, 47: 1055-1059.

Pierpaoli, M.; Randi, E.; Ragni, B.; BirÃš, Z. S.; Szemethy, L.; Herrmann, M.; Hupe, K.; Fernandes, M. (2003). Genetic distinction of wildcat (*Felis silvestris*) populations in Europe, and hybridization with domestic cats in Hungary. *Molecular Ecology,* 12: 2585-2598.

Pimenta, V.; Barroso, I.; Álvares, F.; Correia, J.; Ferrão da Costa, G.; Moreira, L.; Nascimento, J.; Petrucci-Fonseca, F.; Roque, S.; Santos, E. (2005). *Situação Populacional do Lobo em Portugal: Resultados do Censo Nacional 2002/2003*. Relatório Técnico, Instituto de Conservação da Natureza / Grupo Lobo, 158pp + Anexos [In Portuguese].

Piñero, J. (2002). *Mamíferos carnívoros ibéricos*. Lynx Edicions, Bellaterra (Barcelona), Spain, 208 pp. [In Spanish].

Pinheiro, J.C.; Bates, D.M. (2000). *Mixed-Effects Models in S and S-PLUS.* Springer-Verlag, New York, USA. 528 pp.

Pires, A. E.; Fernandes, M. L. (2003). Last lynxes in Portugal? Molecular approaches in a pre-extinction scenario. *Conservation Genetics,* 4: 525-532

Polisar, J.; Maxit, I.; Scognamillo, D.; Farrell, L.; Sunquist, M.E.; Eisenberg, J.F. (2003). Jaguars, pumas, their prey base, and cattle ranching: ecological interpretations of a management problem. *Biological Conservation,* 109: 297-310.

Proulx, G.; Aubry, K.B.; Birks, J.D.S.; Buskirk, S.W.; Fortin, C.; Frost, H.C.; Krohn, W.B.; Mayo, L.; Monakov, V.; Payer, D.C.; Santos-Reis, M.; Weir, R.D.; Zielinski, W.J. (2004). World distribution and status of the genus *Martes* in 2000. *In* Harrison, D.J.; Fuller, A.K.; Proulx, G. (eds.) *Martens and Fishers (*Martes*) in Human-altered Environments: An International Perspective.* Springer Science+Business Media, New York, USA.

Quadros, J. (2002). *Identificação microscópica de pêlos de mamíferos brasileiros e sua aplicação no estudo da dieta de carnívoros.* Doctoral thesis. Universidade Federal do Paraná, Brasil. 133pp. [In Portuguese with English abstracts].

Quigley, H. B.; Crawshaw Jr, P. G. (1992). A conservation plan for the jaguar *Panthera onca* in the Pantanal region of Brazil. *Biological Conservation,* 61: 149-157.

Rabinowitz, A. R.; Nottingham, B. G. Jr. (1986). Ecology and behavior of the Jaguar *(Panthera onca)* in Belize, Central America. *Journal of Zoology*, 210:149-159.

Ramos-Neto, M.B.; Pivello, V.R. (2000). Lightning fires in a Brazilian savanna national park: re-thinking management strategies. *Environmental Management*, 26 (6): 675-684.

Reading, R. P.; Kellert, S.R. (1993). Attitudes toward a proposed blackfooted ferret (*Mustela nigripes*) reintroduction. *Conservation Biology,* 7: 569-580.

Reindl-Thompson, S.A.; Shivik, J.; Whitelaw, A.; Hurt, A.; Higgins, K. (2006). Efficacy of Scent Dogs in Detecting Black-Footed Ferrets at a Reintroduction Site in South Dakota. *Wildlife Society Bulletin,* 34(5): 1435–1439.

Reynolds, J. C.; Aebischer, N. J. (1991). Comparison and quantification of carnivore diet by faecal analysis: a critique, with recommendations, based on a study of the fox *Vulpes vulpes*. *Mammal Review,* 21: 97-122.

Rosenzweig, M.L. (1966). Community structure in sympatric carnivora. *J Mammal,* 47: 602–612.

Roskaft, E.; Andersen, R.; Linnell, J. D. C.; Bjerke, T.; Kaltenborn, B. (2003). Patterns of self-reported fear towards large carnivores among the Norwegian public. *Evolution and Human Behavior,* 24: 184-198.

Ross, P. I.; Jalkotzy, M. G.; Festa Blanchet, M. (1997). Cougar predation on bighorn sheep in southwestern Alberta during winter. *Canadian Journal of Zoology,* 75: 771-775.

Sanderson, E. W.; Redford, K. H.; Chetkiewicz, C. L. B.; Medellin, R. A.; Rabinowitz, A. R.; Robinson, J. G.; Taber, A. B. (2002). Planning to save a species: The jaguar as a model. *Conservation Biology,* 16: 58-72.

Santos-Reis, M. (2003). *De novo no rasto do lince.* [0nline].[Acessed 27th July 2007]. Available from:http://www.naturlink.pt/canais/Artigo.asp.?iCanal=1&iSubCanal=11&iArtigo=11268&iLingua=1 [In Portuguese].

Santos-Reis, M.; Mathias, M. L. (1996).The historical and recent distribution and status of mammals in Portugal. *Hystrix,* 8(1-2): 75-89.

Sarmento, P.; Cruz, J.; Serra, R. (2004). *Conservation Action Plan for the Iberian Lynx in Portugal – Proposal.* ICN, Lisbon. 43pp.

Schullery, P.; Whittlesey, L. H. (1999). Greater Yellowstone Carnivores: A History of Changing Attitudes. *In:* Clark, T. W.; Curlee, A. P.; Minta, S.C.; Kareiva, P.M. (eds). *Carnivores in Ecoysystems: The Yellowstone Experience.* Yale University Press, New Haven, pp. 11-49.

Schwartz, C.C.; Keating, K.A.; Reynolds, H.V.; Barnes, V.G. Jr.; Sellers, R.A.; Swenson, J.E.; Miller, S.D.; Mclellan, B.N.; Keay, J.A.; Mccann, R.; Gibeau, M.L.; Wakkinen, W.L.; Mace, R.D.; Kasworm, W.F.; Smith, R.; Herrero, S.M. (2003). Reproductive maturation and senescence in the female brown bear. *Ursus,* 14: 109-119.

Scognamillo, D.; Maxit, I. E.; Sunquist, M.; Polisar, J. (2003). Coexistence of jaguar (*Panthera onca*) and puma (*Puma concolor*) in a mosaic landscape in the Venezuelan llanos. *Journal of Zoology,* 259: 269-279.

Seymour, K.L. (1989). Panthera onca. *Mammalian Species*, 340: 1–9.

Sillero-Zubiri, C.; Hoffmann, M.; Macdonald D.W. (eds). (2004). *Canids: Foxes, Wolves, Jackals and Dogs. Status Survey and Conservation Action Plan*. IUCN/SSC Canid Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Silveira, L. (2004). Ecologia comparada de onça-pintada (*Panthera onca*) e onça-parda (*Puma concolor*) no cerrado do Brasil. Doctoral Thesis, Universidade de Brasília, Brasília. [In Portuguese].

Silveira, L.; Jácomo, A.T.A.; Diniz-Filho, A.F. (2003). Camera trap, line transect census and track surveys: a comparative evaluation. *Biological Conservation,* 114: 351–353.

Skogen, K. (2003). Adapting adaptive management to a cultural understanding of land use conflicts. *Society and Natural Resources*, 16**:** 435-450.

Smith, D. A.; Ralls, K.; Hurt, A.; Adams, B.; Parker, M.; Davenport, B.; Smith, M. C.; Maldonado, J. E. (2003). Detection and accuracy rates of dogs trained to find scats of San Joaquin kit foxes (*Vulpes macrotis mutica). Animal Conservation*, 6: 339-346.

SNPRCN (1990). *Livro Vermelho dos Vertebrados Terrestres de Portugal. Vol. I – Mamíferos, Aves, Répteis e Anfíbios.* Secretaria do Estado do Ambiente e Defesa do Consumidor, Lisboa, 219 pp. [In Portuguese].

Soisalo, M.K.; Cavalcanti, S.M.C. (2006). Estimating the density of a jaguar population in the Brazilian Pantanal using camera-traps and capture-recapture sampling in combination with GPS radio-telemetry. *Biological Conservation,* 129: 487-496.

SPMA - Secretaria do Planejamento e Meio Ambiente (2000). *Avaliação ecológica rápida do Parque Estadual do Cantão.* Governo do Estado do Tocantins, Palmas, Tocantins, Brazil. [In Portuguese]

Srbek-Araujo, A.C.; Chiarello, A.G. (2005). Is camera-trapping an efficient method for surveying mammals in Neotropical forests? A case study in south-eastern Brazil. *Journal of Tropical Ecology,* 21:121–125.

Sunquist, M.; F. Sunquist. (2002). *Wild cats of the world*. Chicago, University of Chicago Press. 452 pp.

Szinovatz, V. J. (1997). *Attitudes of the Norwegian public toward bear and lynx*. Diploma Thesis at the Institute of Wildlife Biology and Game Management, University of Agricultural Sciences in Vienna, Austria.

Taber, A.B.; Novaro, A.J.; Neris, N.; Colman, F.H.(1997). The Food Habits of Sympatric Jaguar and Puma in the Paraguayan Chaco. *Biotropica,* 29: 204-213.

Teerink, B.J. (1991). *Hair of west-european mammals – Atlas and identification key*. Cambridge University Press, Cambridge, 224 pp.

Terborgh, J.; Estes, J.A.; Paquet, P.; Ralls, K.; Boyd-Heigher, D.; Miller, B.J.; Noss, R.F. (1999). The role of top carnivores in regulating terrestrial ecosystems. *In*: Terborgh, J.; Soulé, M. (eds). *Continental conservation: scientific foundations of regional reserve networks.* Washington DC, Island Press, pp. 39–64.

Treves, A.; Karanth, K.U. (2003). Human-carnivore conflict and perspectives on carnivore management worldwide. *Conservation Biology,* 17(6): 1491–1499.

Trindade, A.; Farinha, N.; Florêncio, E. (1998). A distribuição da lontra *Lutra lutra* em Portugal —situação em 1995. ICN, Lisbon, 138 pp. [In Portuguese]

Trites, A. W.; Joy, R. (2005). Dietary analysis from fecal samples: how many scats are enough? *J. Mammal.* 86:704−712.

Tucker, P.; Pletscher, D. (1989). Attitudes of hunters and residents towards wolves in northwestern Montana. *Wildlife Society Bulletin*, 17: 509-514.

Vidal-Figueroa, T.; Delibes, M. (1987). Primeros datos sobre el visón americano (*Mustela vison*) en el suroeste de Galicia y noroeste de Portugal. *Ecologia,* 1: 145-152 [In Spanish].

Virgos, E.; Llorente, M.; Cortes, Y. (1999). Geographical variation in genet (*Genetta genetta* L.) diet: A literature review. *Mammal Review,* 29: 117-126.

Vitt, L. J.; Shepard, D. B.; Caldwell, J. P.; Vieira, G. H. C.; França, F. G. R.; Colli, G. R. (2007). Living with your food: geckos in termitaria of Cantão. *Journal of Zoology,* 272(3): 321-328.

Wasser, S. K.; Ramage, E. R.; Hunt, K. E.; Davenport, B.; Clarke, C.; Parker, M.; Stenhouse, G. (2004). Scat detection dogs in wildlife research and management: Application to grizzly and black bears in the Yellowhead Ecosystem, Alberta, Canada. *Canadian Journal of Zoology*, 82: 475-492.

Weaver, J. L. (1993). Refining the equation for interpreting prey occurrence in gray wolf scats. *Journal of Wildlife Management,* 57: 534-538.

Wechselberger, M.; Rigg, R.; Beťková, S. (2005). *An investigation of public opinion about the three species of large carnivores in Slovakia: brown bear (*Ursus arctos)*, wolf (*Canis lupus*) and lynx (*Lynx lynx*)*. Slovak Wildlife Society, Liptovský Hrádok. x + 89 pp.

Weckel, M.; Giuliano, W.; Silver, S. (2006a). Jaguar *(Panthera onca)* feeding ecology: Distribution of predator and prey through time and space. *Journal of Zoology,* 270: 25-30.

Weckel, M.; Giuliano, W.; Silver, S. (2006b). Cockscomb revisited: Jaguar diet in the Cockscomb Basin Wildlife Sanctuary, Belize. *Biotropica*, 38: 687-690.

Williams, C.K.; Ericsson, G.; Heberlein, T.A. (2002). A quantitative summary of attitudes toward wolves and their reintroduction (1972-2000). *Wildlife Society Bulletin*, 30(2): 575-584.

Willson, M. F. (1993). Mammals as seed-dispersal mutualists in North America. *Oikos*, 67: 159-176.

Woodroffe, R.; Ginsberg, J. R. (1998). Edge effects and the extinction of populations inside protected areas. *Science*, 280: 2126–2128.

Woodroffe, R.; Ginsberg, J.G. (2005). King of the beasts? Evidence for guild redundancy among large mammalian carnivores. *In*: Ray, J.; Berger,J.; Redford, K.H.; Steneck, R. (eds.). *Large carnivores and biodiversity.* Island Press, New York. pp. 154-176.

Woodroffe, R.; Thirgood, S.: Rabinowitz, A. (eds) (2005). *People and Wildlife, Conflict or Coexistence?*. Cambridge University Press, Cambridge, UK. 498 pp.

WWF-UK (2000). *Tourism and carnivores - the challenge ahead.* The Centre for Responsible Tourism, UK. [0nline]. [Acessed 2nd August 2007]. Available from: http://www.icrtourism.org/Publications/tourism&carnivores.pdf

Zielinsky, W. J. (2004). The status and conservation of mesocarnivores in the Sierra Nevada. *Proceedings of the Sierra Nevada Science Symposium*: 2002 October 7-10; Kings Beach, CA. Gen. Tech. Rep. PSW-GTR-193. Albany, CA: Pacific Southwest Research Station, Forest Service, U. S. Department of Agriculture; pp 185-194.

Zimmerman, B.; Wabakken, P.; Dotterer, M. (2001). Human–carnivore interactions in Norway: how does the re-appearance of large carnivores affect people's attitudes and levels of fear? *Forest, Snow, and Landscape Research*, 76: 137–153.