THE IMPACT OF PUMA PREDATION AND HUMAN HARASSMENT ON TWO SPECIES OF THREATENED WILD SOUTH AMERICAN CAMELIDS: A REGIONAL AND SEASONAL ASSESSMENT IN PROTECTED AREAS OF NORTH WESTERN ARGENTINA

Technical Report to the Rufford Small Grants Foundation

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November 2007

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Summary

South American camelids (SAC), guanacos *Lama guanicoe* and vicuñas *Vicugna vicugna*, have dramatically declined by more than 90% during the last century due to human related activities. In northwestern Argentina, relict SAC populations are mostly isolated in protected areas, where poaching seems to play an important role affecting SAC abundance and persistence. In addition, the reduction of SAC populations resulted in the loss of the interaction between SAC and their only effective predator, the puma *Puma concolor*, with pumas mostly preying on introduced species. Preliminary data collected in 3 reserves showed that poaching was common in some, and puma predation was high in all reserves. In the reserves with poaching, we observed that SAC became noticeably wary; the presence of humans forced them to leave their foraging areas. Diet data showed that pumas heavily preyed on SAC, suggesting that the interaction SAC-puma was being conserved in the reserves we had surveyed. The extent to which other reserves in northwestern Argentina successfully protect SAC populations and conserve the interaction SAC-puma is unknown. Therefore, we extended our research on SAC flight behavior and SAC-puma interactions to 4 national parks on northwestern Argentina (for a total of 7 reserves surveyed). In addition, we conducted, at one park, seasonal surveys to evaluate whether SAC flight behavior responses and SAC-puma interactions varied on a seasonal basis. We found that the degree to which reserves effectively protect SAC populations seemed to depend on whether federal or provincial governments are responsible for management and law enforcement. We observed that SAC took flight less frequently after detecting a vehicle at national (federal) parks than at provincial reserves. Such observations were correlated with different levels of poaching activity. Also, we found that flight responses were robust to seasonality. We provided each reserve and park with quantitative baseline information, a sampling design and training that will allow park rangers monitoring SAC flight behavior responses to human activity in a continuous basis. Also, we provided a tentative threshold value that could be used in other protected and non-protected areas to evaluate the degree to which humans are – or are not – harassing SAC populations. Our data on puma diet showed that only two parks appeared to be conserving the interaction SAC-pumas. However, the situation did no seem to be catastrophic in the remaining parks, where other native prey species composed the bulk of the diet of pumas. Low frequency of occurrence of SAC remains in puma scats at some parks was likely due to artificially (i.e. human induced) low SAC densities. Because national parks are improving law enforcement and deterring poaching, we predict an increase on SAC numbers followed by an increase of SAC occurrence in puma scats. Our research provided baseline information on SAC relative and absolute abundances, and SAC occurrence on puma scats that would allow testing the above mentioned prediction within the following 5-10 years. Along with baseline information, we also provided sampling protocols and training that allow developing of a monitoring plan for the interaction SAC-puma and SAC population trends at each park. In addition to data on SAC and pumas, we generated baseline abundance data for several mammal species in all the protected areas we visited; we collected, analyzed and reported relative and absolute densities for several species of mammals including native and exotic species. Overall, we produced quantitative information, which will become important conservation and management assets for most of the parks we surveyed.

Section I. – Flight behavior in guanacos and vicuñas in protected areas of northwestern Argentina: regional and seasonal patterns

Introduction

Once widespread in the arid and semi-arid landscapes of South America, wild South American camelids (SAC), guanacos *Lama guanicoe* and vicuñas *Vicugna vicugna*, have became scarce throughout their ranges, with current populations representing <10% of those first observed by Europeans (Koford, 1957; Raedeke, 1979; Torres, 1992). Distributions of both species have declined correspondingly. In Argentina, the present geographic ranges of guanacos and vicuñas are about 40-56% and 75% of the original ranges, respectively (Cajal, 1991; Franklin et al., 1997). Of these areas, only 3% of the range of guanacos and 34% of that of vicuñas fall within reserves (Cajal, 1991).

Although the hunting of camelids is prohibited within reserves, interviews with local residents, park rangers and park managers suggest that poaching occurs, with different levels of intensity, in some of them. In fact, data collected in three reserves of northwestern Argentina showed that poaching was common in two of them, and that this activity had an impact on the behavior of SAC (see below; Donadio and Buskirk 2006). Such observations raised concern about the extent to which reserves in Argentina effectively preserve populations of SAC.

A direct assessment of SAC mortality due to poaching is difficult because poachers usually remove carcasses of hunted animals and scavengers consume offal. However, an indirect assessment may be possible; the harassment caused by chasing and shooting may modify camelid behaviors, with individuals becoming more wary in those areas where they are harassed. Indeed, our previous work showed that SAC under human harassment tend to flee more often from humans and have longer flight distances and shorter flight times than those that are not harassed (Donadio and Buskirk 2006). Similar responses to human harassment have been reported for other ungulate species, including white-tailed deer *Odocoileus virginianus* (Kilgo et al., 1998), roe deer *Capreolus capreolus* (de Boer et al., 2004), elk *Cervus elaphus* (Bender et al., 1999), reindeer *Rangifer tarandus* (Baskin and Hjältén, 2001), and impala *Aepycerus melampus* (Setsaas et al. 2007).

Besides human harassment, other factors such as species, group size and composition, and season of the year may influence ungulate flight responses (Cederna and Lovari 1985, Recarte et al.1998, Borkowski 2001, Taylor and Knight 2003, Fortin and Andruskiw 2003). Understanding how these factors interact with human harassment to shape SAC flight responses is important to accurately interpret them. In 2004, we evaluated whether (1) SAC species responded differently to similar levels of human harassment, (2) the number of individuals in a group influenced SAC flight responses, and (3) the presence or absence of juveniles (< 1 year old) influenced SAC flight responses. We found that none of these factors had a significant effect on how SAC responded to different levels of human harassment; flight frequency, flight distance, and time to first flight were independent from species, group size, and group composition (Donadio and Buskirk 2006). However, our 2004 field season took place in winter; therefore, we were unable to evaluate the potential influence of seasonality on SAC flight responses.

During the extent of the 2006-07 field season, our goals were to (1) extend our research on SAC flight behavior to other areas within the San Guillermo – Laguna Brava landscape[1], and to four additional reserves of northwestern Argentina, and (2) use our previous collected data on SAC flight behavior as a base line to assess the degree to which SAC were being protected not at a local but at regional scale. In addition, at one national park (San Guillermo National Park [SGNP]), we studied whether SAC flight behavior responses varied among seasons. We did so to evaluate the robustness of flight indexes (i.e. indexes of human harassment) to within year seasonal variation.

Methods

Study areas

Laguna Brava Provincial Reserve (LBPR), San Guillermo Provincial Reserve (SGPR) and SGNP are three contiguous reserves located in northwestern Argentina. LBPR is located in La Rioja province, while SGPR and SGNP are located in San Juan province. Overall, they encompass a 1.4 million-ha area that ranges from 28°27' – 29°55' S to 68°45' – 70° 02' W and lies within one of the most ecologically intact regions of South America (Sanderson et al., 2002). Elevation ranges from 2,000 to 6,800 m. Large sympatric populations of guanacos and vicuñas inhabit the area. A thorough description of the study site can be found in Donadio and Buskirk (2006) and a technical report submitted to the RSG Foundation (Donadio 2005).

Talampaya National Park (TNP), also in La Rioja province, encompasses 215,000 ha located at 29°46' S – 67°54' W. Vegetation is characterized by a shrubby steppe with a high percentage of bare ground. Mean elevation is 1,300 m. The weather is dry (150 to 170 mm

[1] In 2004, we collected data in the San Guillermo – Laguna Brava landscape. This landscape is composed of three reserves with different levels of poaching activity: San Guillermo National Park (poaching nil), San Guillermo Provincial Reserve, southeast portion (poaching frequent), and Laguna Brava Provincial Reserve (poaching frequent). For more information about these areas see Donadio and Buskirk (2006).

precipitation/year) with extreme temperatures in both winter (-9°C) and summer (above 50°C). A small population of guanacos inhabits the park, while vicuñas are absent. El Leoncito National Park (ELNP), in San Juan province, encompasses 76,000 ha located at 31°46' S – 69°10' W. Vegetations is characterized shrubby steppes and high altitude semi arid grasslands. Elevation ranges from 1,600 to 4,300 m. The weather is dry (200 mm precipitation/year) and cold (mean annual temperature 15°C). In the park, guanacos are abundant, while vicuñas are absent. Sierra de las Quijadas National Park (SQNP), in San Luis province, encompasses 150,000 ha located at 32°29' S – 67°02' W. Vegetation is represented by a shrubby steppe and small stands of thorny trees. With a few exceptions, elevation does not exceed 1,000 m. The weather is dry, with precipitations occurring mainly in summer (200 mm/year); temperatures vary from low in winter (monthly mean 3.1°C) to high in summer (monthly mean 31°C). A small relictual population of guanacos can be found in the park. Los Cardones National Park (LCNP), in Salta province, encompasses 65,000 ha located at 25°15' S – 65°54' W. A shrubby steppe, saguaros, small stands of thorny trees, and high altitude grasslands characterize the vegetation. Elevation within the park ranges from 2,700 to 5,000 m. The weather is dry, with 90% of the precipitations occurring in summer (200 mm/year). In winter, mean annual temperature is 11°C and in summer is 18°C. A small, apparently increasing, population of guanacos inhabits the park. A map (1 and 2) showing the location of all the reserves is presented in p 47.

In all reserves, pumas seemed to be abundant. Exotic species, potential prey for pumas, varied depending on the reserve. European hares were present in all reserves. Similarly, livestock (sheep, goats, cattle, and horses) was present in all reserves. Feral donkeys were observed at TNP, SQNP, LCNP and some areas of SGPR. Abundances of livestock depended on the reserve. SGNP had the lowest abundance of livestock (< 25 animals). At LBPR, SGPR, TNP, SQNP and LCNP goats, sheep and cattle were abundant (up to 3,300 goats, 2,000 sheep and 1,600 cows in some reserves)[2].

We qualitatively assessed levels of human harassment (i.e. poaching) in each reserve based on (1) our previous experience working in the San Guillermo – Laguna Brava landscape (this includes LBPR, SGPR and SGNP) and (2) interviews with park rangers and managers (for all reserves). Within the San Guillermo – Laguna landscape we were able to differentiate areas that were frequently visited by poachers from those areas that were not. For TNP, SQNP, LCNP and

[2] With one exception (LCNP), park rangers could not provide us with reliable estimates of livestock grazing within the limits of the reserves. However, in all these reserves livestock was observed in large numbers.

ELNP we lacked any previous knowledge on poaching activity; therefore, we asked park rangers to assess poaching activity only for those parts of the park we were going to survey.

Field sampling

In winter ‘04, data were gathered at LGPR, SGPR, and SGNP from June to August (see Donadio and Buskirk 2006, Donadio 2005 [report to the RSG]). In autumn ‘05, data were gathered at LGPR, SGPR, and SGNP during April. Field work supported by the RSG 2nd grant took place (1) at SGNP in summer ‘06 (February), winter ‘06 (June), spring ‘06 (October), and summer ‘07 (February), and (2) at TNP, ELNP, SQNP, and LCNP in winter ‘06 (July and August).

Line transects of variable length (3.2 - 26.5 km), at least three in each reserve, were defined based on the distribution of dirt roads and tracks, and the likelihood of observing SAC from these roads. Transects were traveled by vehicle (speed 20 - 35 km/h) with two observers standing in the back. Each transect was traveled one to four times. Surveys were conducted between 9 am and 4 pm.

Three flight responses were recorded: frequency of flight behavior, flight distance, and time to first flight. Frequency of flight behavior was evaluated by defining three response categories: (1) staying - animals became more alert but did not flee; (2) walking away - animals slowly moved away from the vehicle but did not leave their grazing grounds; and (3) fleeing - animals galloped out of the sight of the observer and left their grazing grounds. For statistical analyses, the first two categories were aggregated in the “*staying*” category (coded as 0) because groups displaying these two responses were relatively little disturbed when compared to those that galloped away (coded as 1). Animals were considered members of the same group if they exhibited cohesive behavior. Within a group, the behavior of the first reacting animal was considered the behavior of the group.

Flight distance was defined as the minimum distance to the vehicle approaching in the road at which animals started an evasive response. Time to first flight was defined as the time between when the animals detected our presence and initiated an evasive response. Flight distances were measured to the center of the group using a range finder (Bushnell Yardage Pro 1000). Flight response times were measured to the nearest second using a stopwatch. All flight responses were recorded, with the aid of binoculars when necessary, for groups no farther than *ca.* 1000 m from the road.

Data analysis

Frequency of flight behavior (as a percentage), flight distance, and time to first flight data were analyzed using resampling methods. Specifically, we used bootstrap analysis to estimate mean values for each flight response and their associated 95% CI's. For each data set, we drew *n* number of observations (resample) randomly, and with replacement, and estimated the mean of this resampled set. This procedure was repeated 1000 times (iterations); resampled means were recorded each time. From this collection of means, we estimated the overall mean and 95% CI's, which where calculated by finding the 2.5th and 97.5th percentiles (Resampling Stats Inc 2006).

Frequency of flight behavior responses were listed as a collection of zeros and ones. Resample size (number of values in each resample or shuffle) was equal to 100. Conversely, for flight distance and time to first flight data resample size was equal to sample size (number of values in the original data set). As a general rule, we conducted these analyses only for those data sets where $n \geq 10$. In all cases, we used the program Resampling Stats Add-In for Excel User's Guide (Resampling Stats Inc 2006).

Results

Frequency of SAC flight behavior at 7 protected areas of northwestern Argentina

Mean percentage, and associated 95% CI's, of SAC groups (n = 1,650) fleeing after detecting a vehicle at 7 reserves of northwestern Argentina is shown in fig. 1; for SGNP and LGPR data is arranged by year and season. Overall, SAC fled more frequently in provincial reserves (mean % of fleeing groups > 62.8%) than in national parks (< 40.5%), the only exception being ELNP, where 50% of SAC groups took flight after detecting our vehicle. Lack of data precluded a similar analysis for SQNP.

Frequency of SAC flight behavior in the San Guillermo – Laguna Brava landscape

In this landscape, between winter '04 and summer '06 we collected information on frequency of flight behavior from 1,425 SAC groups. Mean percentage, and associated 95% CI's, of SAC groups fleeing or staying after detecting a vehicle at different areas within the landscape is shown in fig. 2. Overall, SAC took flight more frequently (> 64.2% of the groups fled) in the eastern area of LBPR, Médanos – in the southeastern portion of SGPR – and Jagüelito a site located within the mining area and under the control of the mining company. Conversely, SAC groups took flight less frequently (< 35.7% of the groups fled) in the northern portion of SGPR, along the main mining road, Del Carmen – a secondary mining road – and in the northern and central portion of SGNP. In-between responses (40 to 55% of the groups fled) were observed in the western portion of, and the southern access to LBPR, and the southern portion of SGNP.

Flight distance and time to first flight at 5 national parks

During winter '06, we collected data on these variables at SGNP (only vicuñas) and ELNP (guanacos); for comparative purposes, we included data collected at SGNP for guanacos in winter '04. Mean flight distances, and associated 95% CI's, are shown in fig. 3A. Data from winter '06 showed that SAC flight distances were similar in SGNP (vicuñas: mean flight distance = 250.1 m) and ELNP (guanacos: 281.1 m). Conversely, mean guanaco flight distance was larger at SGNP during winter '04 (596.6 m). Mean time to first flight values, and associated 95% CI's, are shown in fig. 4A. Data from winter '06 showed that SAC mean time to first flight was similar in SGNP (vicuñas: mean time to first flight = 32.4 s) and ELNP (guanacos = 27.7 s), and shorter than that observed for guanacos at SGNP during winter '04 (52.8 s). Small number of observations in winter '06 impeded similar analyses for guanacos at SGNP, TNP, LCNP and SQNP.

Robustness of flight response indexes to seasonality at SGNP

SAC frequency of flight behavior appeared to vary slightly among seasons. The only exception occurred in fall (October '06), when both species of SAC took flight less frequently than in summer (February '06 and '07) and winter (June '06; fig. 5). SAC flight distances were not affected by season, at least for vicuñas (no data available for guanacos); however, our data on this variable is restricted to only two seasons (fig. 3B). SAC (only vicuñas) times to first flight remained more or less constant in all seasons, but fall (October '06), when time to first flight became noticeably shorter (fig. 4B).

Conservation and management implications

Frequency of SAC flight behavior at 7 protected areas of northwestern Argentina

In northwestern Argentina, the degree to which reserves effectively protect SAC populations seems to depend on whether federal or provincial governments are responsible for management and law enforcement. We observed that SAC took flight less frequently after detecting a vehicle at national parks than at provincial reserves. This behavior agrees with qualitative information on poaching activity provided by park rangers and reserve managers. At SGNP, TNP, and LCNP park rangers informed us that poaching was nil (≤ 1 poaching incidents per month); this correlated with the low percentage of fleeing groups that we observed in those parks. At ELNP, park rangers informed us that poaching activity was infrequent (2 to 5 poaching incidents per month); this correlated with an intermediate percentage of fleeing groups. Finally, at the provincial reserves LBPR and SGPR, data provided by reserve managers and our own observations suggested that poaching was frequent (≥ 6 poaching incidents per month); these observations correlated with the high percentage of fleeing groups that we observed at those reserves.

Differences in levels of vigilance and law enforcement between national parks and provincial reserves are mainly due to lack of political interest in implementing provincial protected areas. This translates into a lack of proper funding resources. Such pattern is currently being reversed at least in SGPR. Here, the government of San Juan province has recently provided enough funding to increase levels of patrolling within the reserve limits. Our previous and current work in the area (see *Frequency of SAC flight behavior in the San Guillermo – Laguna Brava landscape*) are being used to determine which areas inside the reserve are more frequently visited by poachers; also, our research on flight behavior provided indexes that would be used to assess the efficiency of patrolling in deterring poachers from the reserve.

Frequency of SAC flight behavior in the San Guillermo – Laguna Brava landscape

We extended our research on flight behavior to 6 new areas within the 1.4 million-ha encompassed by the San Guillermo-Laguna Brava landscape. The combined analysis of prior (Donadio and Buskirk 2006) and new data allowed us to create a map of flight responses for almost the entire landscape (fig. 2). Human harassment of SAC seemed to not be widespread in the landscape. Indeed, harassment was localized to areas ([2] and [8] in fig. 2) that lacked any management oversight and were easy to access due to the presence of dirt roads in good condition. These areas were within both provincial reserves, LBPR and RBPR. Areas where SAC did not perceived humans as a threat were those that were highly isolated ([1] in fig. 2), or frequently patrolled by either staff from the mining companies ([4], [5] and [6] in fig. 2) or park rangers ([10] and [11] in fig. 2). In area [7], SAC perceived humans as a threat and fled frequently after detecting us. This observation was puzzling since the area is under the control of mining companies, which were successful at deterring poachers. Miners informed us that area [7] is regularly visited by soldiers who often shot at SAC groups; such activity would explain the behavior displayed by SAC in that area.

Overall, whether human harassment occurs or not within the San Guillermo-Laguna Brava landscape seemed to be a function of the degree of isolation and/or patrolling of each area. We conclude that human harassment and its negative impact on SAC populations is reversible in the landscape. Increasing levels of patrolling in those areas signaled by our study and closing dirt roads opened by mining companies would surely represent adequate conservation measures. Our baseline data on SAC flight behavior could be used to monitor the efficiency of such measures.

Flight distance and time to first flight at 5 national parks

We recorded flight distance and time to first flight only at SGNP and ELNP, where SAC were most abundant. Flight distances for guanacos were larger at SGNP than at ELNP, while time to first flight was shorter at the former park. These results are contradictory as we expected larger flight distances associated with shorter times to first flight at ELNP, where poaching activity, although infrequent, was reported to be more important than at SGNP. Discrepancies between expected and observed flight distances have been reported for sika deer (*Cervus nippon*; Borkowski 2001) and SAC (Donadio and Buskirk 2006). We suggest avoiding the use of flight distance to evaluate levels of human harassment on SAC until a more thorough assessment of the factors that could potentially affect this variable is conducted.

Robustness of flight response indexes to seasonality at SGNP

The frequency of SAC flight behavior remained essentially constant regardless of the season of the year. The only exception was observed during the spring ’06, when SAC groups became less wary and fled less frequently; such pattern was observed for guanaco and vicuña groups. We do not know why SAC groups behaved differently in spring ’06. More spring surveys will be needed to assess whether the behavior we observed during this season represents a general pattern or an outlier. Meanwhile, we suggest park managers to avoid comparisons of flight frequency responses between seasons if one data set was collected in spring.

Flight distances remained constant regardless the season of the year. However, data was collected only in summer and winter ’06. Time to first flight remained essentially constant in all seasons but spring ’06, when SAC groups took flight significantly sooner. As for spring data on frequency of flight behavior, we lack an explanation for this observation. Notably, in spring, SAC groups tended to take flight less frequently, but those that took flight did it sooner than in other seasons.

Despite the differences we observed in spring, flight responses appear to be relatively robust to seasonality. Likewise, Donadio and Buskirk (2006) reported that SAC flight responses were independent from group size and group composition (presence or absence of juveniles). Overall, SAC flight responses, particularly frequency of flight behavior, appear as reasonable and easy-to-implement variables to monitor SAC behavioral responses to human disturbance.

Figure 1. – Percentage of groups (95% CI) of wild South American camelids that fled after observing a vehicle in 6 different reserves with different levels of human harassment in northwestern Argentina. Broken vertical line represents a potential threshold that could be used as an alarm sign to detect SAC harassment by humans. Solid red = high levels of harassment; solid yellow = intermediate levels of harassment; solid grey = harassment infrequent to nil. ELNP = El Leoncito National Park; LCNP = Los Cardones National Park; TNP = Talampaya National Park; SGPR = San Guillermo Provincial reserve; LBPR = Laguna Brava Provincial Reserve. No data available for Sierra de las Quijadas National Park. Gua = guanaco; vic = vicuña; *n* = total number of groups observed. Data for SGPR represent observations recorded only in Médanos (see fig. 2); data for LBPR represent observations recorded in the western and central portion of the reserve (see fig. 2).

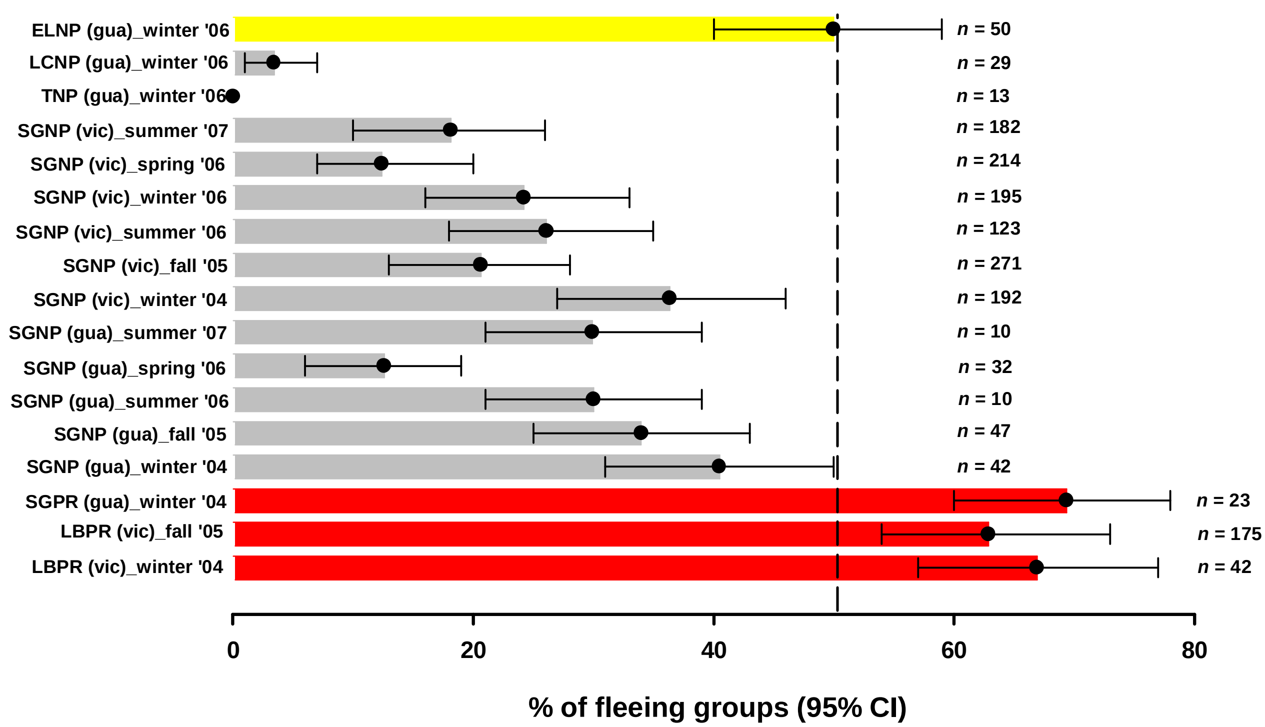


Figure 2.- Percentage of groups of wild South American camelids that fled after detecting a vehicle in different areas of the San Guillermo – Laguna Brava landscape (data is for both camelid species combined). LBPR: [1] western area (*n* = 62; mean % [95% CI] = 43.5 [34-53]), [2] eastern area (*n* = 290; 64.2% [55-74]), [3] southern access (*n* = 22; 45.2% [35-54]); SGPR: [4] northern area (*n* = 112; 34.9% [26-44]), [5] main mining road (*n* = 39; 35% [27-46]), [6] secondary mining road – Del Carmen (*n* = 9; 11.2% [5-18]), [7] secondary mining road – Jagüelito (*n* = 6; 66.6% [57-75]), [8] Médanos (*n* = 46; 78.4% [70-86); SGNP: [9] southern area (*n* = 143; 50.9% [41-61]), [10] central area (*n* = 142; 35.7% [27-45]), [11] northern area (*n* = 554; 25.9% [18-35]); *n* = sample size. Percentage of groups that stayed is shown in red (confidence intervals not reported).

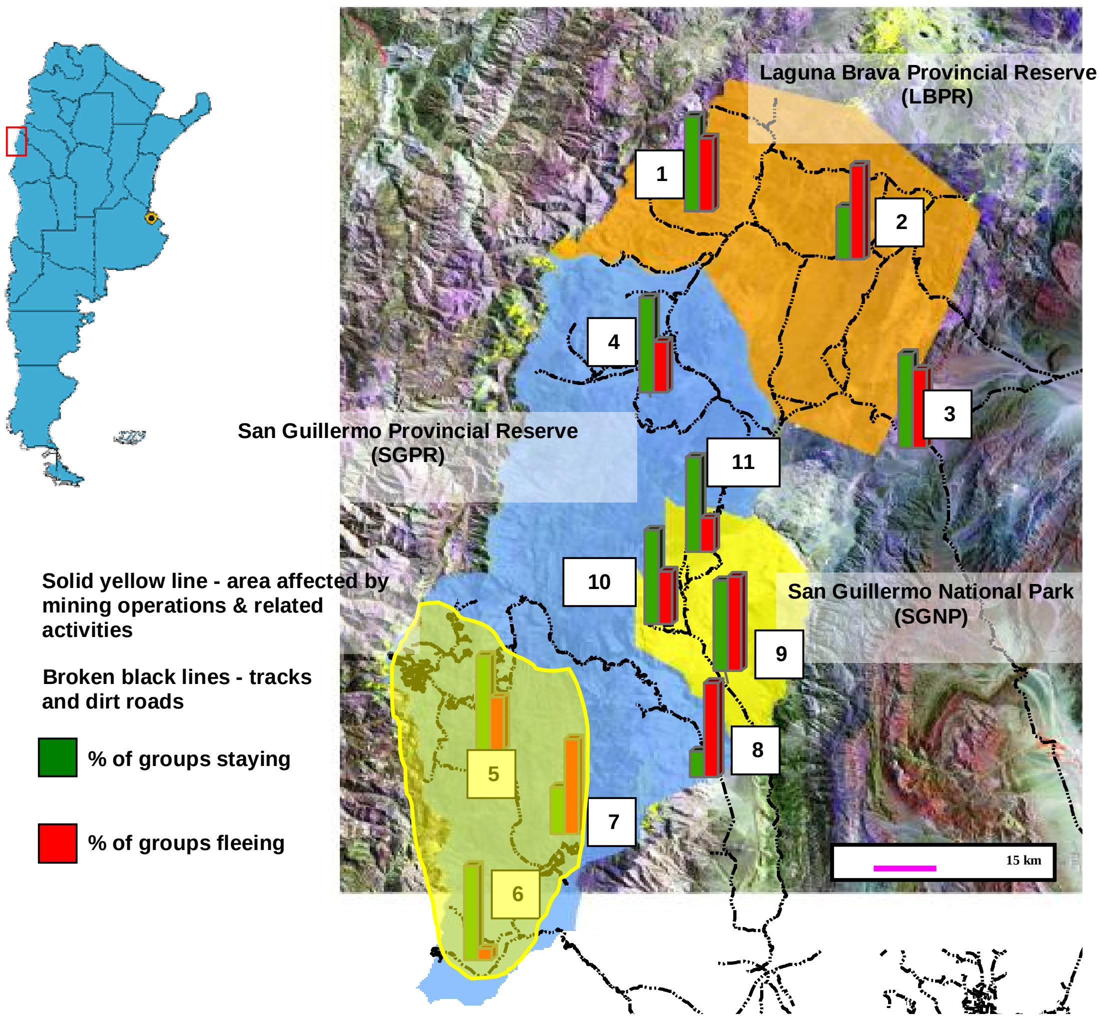


Figure 3.– Mean flight distances (95% CI) of SAC groups in two different national parks (A) and seasons (B). SGNP = San Guillermo National Park; ELNP = El Leoncito National Park. Vic = vicuña; gua = guanaco; *n* = sample size. [1] Data from June ’04.

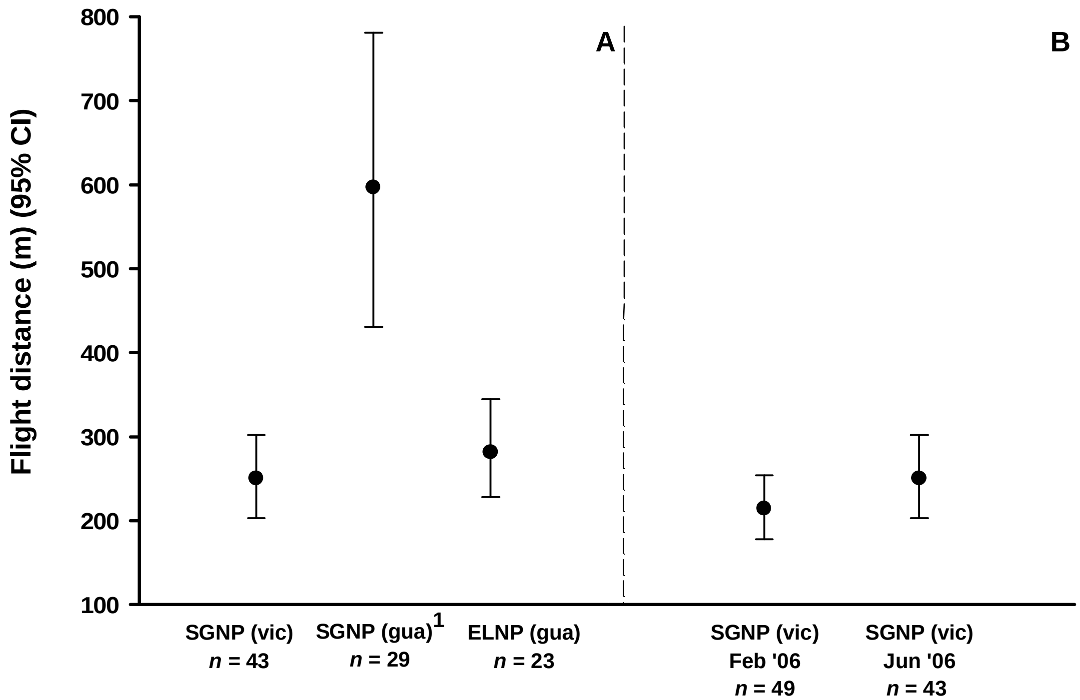


Figure 4. – Mean time to first flight (95% CI) of SAC groups in two different national parks (A) and four different seasons (B). SGNP = San Guillermo National Park; ELNP = El Leoncito National Park. Vic = vicuña; gua = guanaco; *n* = simple size. [1] Data from June ’04.

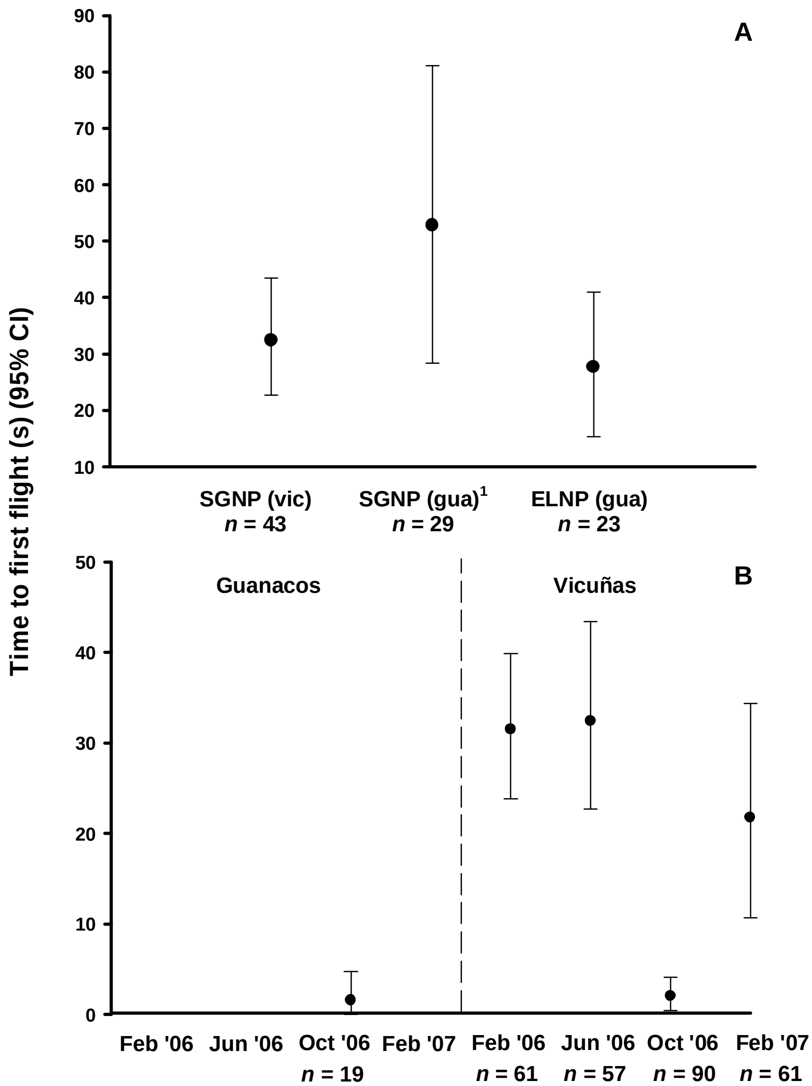
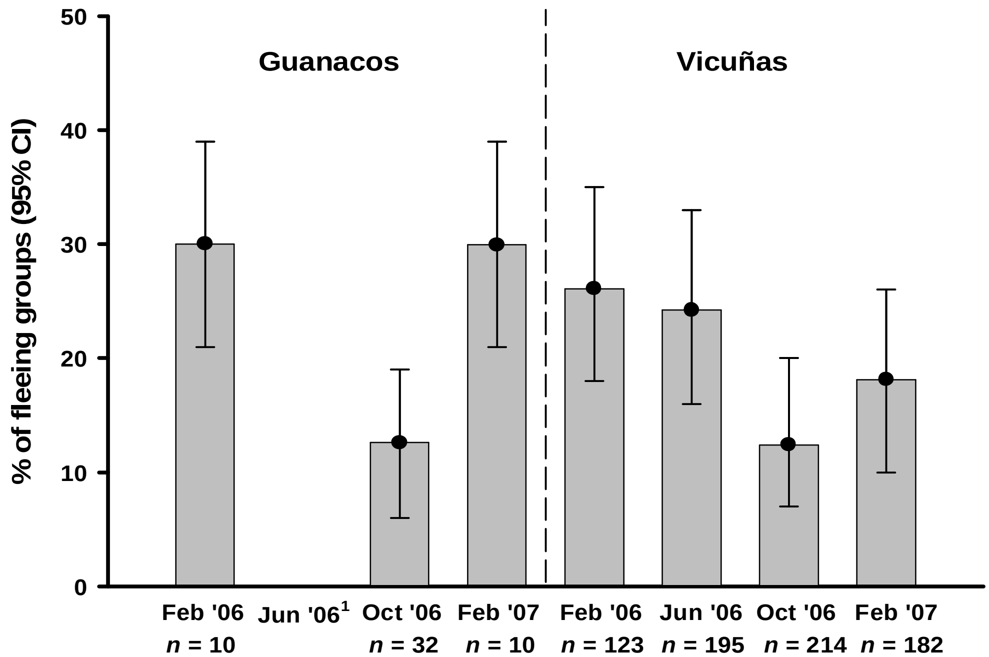


Figure 5. - Percentage of groups (95% CI) of wild South American camelids that fled after observing a vehicle in 4 different seasons at San Guillermo National Park, northwestern Argentina. [1] Data not analyzed due to small sample size (n = 7).



Section II. – Puma predation on wild South American camelids: are reserves of northwestern Argentina conserving a potentially strong interaction?

Introduction

Historically, wild South American camelids (vicuñas *Vicugna vicugna* and guanacos *Lama guanicoe*; SAC) were the main prey of the puma in the Patagonian steppe and the highland plateau (Puna) of South America (Miller 1980). During the last 150 years, over hunting and competition with livestock, mainly sheep, resulted in a catastrophic reduction in the number and geographic range of SAC populations (Franklin 1982; Cajal 1991; Franklin et al. 1997; Baldi et al. 2001). Consequently, this predatory interaction has been lost through most of the original zone of sympatry in the semiarid landscapes of South America, with pumas now preying mostly on introduced lagomorphs and other exotic species (Rau et al. 1991; Novaro et al. 2000; Novaro and Walker 2005).

In southern South America, the interaction SAC-puma appear to persist only in some protected areas. In Torres del Paine National Park (southern Chile), where guanacos have increased their densities during the last 25 years, the occurrence of guanaco remains in puma scats increased by 300% (Iriarte et al. 1991). Since Iriarte et al.'s study, a high incidence of puma-caused mortality has been observed in the same population of guanacos (Sarno et al. 1999, Franklin et al. 1999). At San Guillermo National Park (SGNP), in the high Andes of northwestern Argentina, Cajal and Lopez (1987) found that, during the period 1978-1984, 14.5% of guanaco carcasses (n = 89) and 9.7% of those of vicuñas (n = 186) had signs of puma predation.

Likewise, our preliminary work in SGNP and two contiguous reserves (Laguna Brava Provincial Reserve [LBPR] and San Guillermo Provincial Reserve [SGPR]) during the period 2004-06 showed that pumas heavily prey on SAC. Indeed, analysis of 174 puma scats revealed that camelids made up ≈ 85% of the total biomass consumed by this predator (Donadio et al. 2005). Furthermore, an analysis of 137 camelid carcasses (guanaco n = 64 and vicuña n = 73) showed that 31% and 40% of guanaco and vicuña carcasses, respectively, presented signs of puma predation (Donadio et al. 2006).

Recently, several observational and experimental studies highlighted the importance of the interaction between large carnivores and their ungulate prey to ecosystems. For instance, wolves might have positively influenced aspen (*Populus* spp.) and willow (*Salix* spp.) recruitment by reducing the impact of various ungulate species on vegetation (Ripple and Larsen 2000, Ripple and Beschta 2004). The local extinction of wolves and grizzly bears (*Ursus arctos*) in western

USA triggered a cascade of ecological events that allowed the eruption of a large herbivore, the moose (*Alces alces*) and negatively affected riparian vegetation and avian neotropical migrants, which used these riparian vegetated areas to reproduce (Berger et al. 2001). Experimental exclosures simulating the removal of large herbivores (i.e. imitating the effects of large carnivores) in African savannas resulted in an increase of both small herbivore rodents and olive hissing snakes (*Psammophis mossambicus*), which showed a numerical response to increasing abundances of small-mammal prey (McCauley et al. 2006).

Data from Chile and Argentina suggest that, where they still coexist, pumas and SAC interact strongly. Therefore, we explored whether several national parks of northwestern and central Argentina are conserving such interaction. To advance our understanding on SAC-puma interactions, we also expanded our research in SGNP by analyzing puma diet and SAC mortality on a seasonal basis. During the extent of the 2006-07 field season, our specific goals were, at each park, to (1) estimate SAC and alternative puma prey (i.e. exotic European hares *Lepus europaeus*) densities, (2) determine the composition of puma diet based on scat analysis and (3) evaluate the degree to which pumas consumed exotic and native prey species. In addition, at SGNP, we (1) estimated SAC and European hare densities, (2) determined puma diet from scats and (3) explored puma prey selection patterns from SAC carcass collection, on a seasonal basis.

Methodology

Study area

See *Study Area* in Section I.

Field sampling

SAC and European hare density, and puma diet data were gathered in summer ‘06 (February), winter ‘06 (June), spring ‘06 (October) and summer ‘07 (February) at SGNP. Similar information was collected at TNP, ELNP, SQNP, and LCNP in winter ‘06 (July and August). Additional puma scats were collected by park rangers in the latter four parks from September ‘06 to February ‘07.

To estimate SAC and European hare absolute densities we established a minimum of three transects of variable length in each park. Transects were established based on the availability of dirt roads and tracks. Each transect was traveled at least once (maximum 4 times) during daylight (SAC surveys) and night (hare surveys). Hare counts were made with the aid of spotlights. Species, number of individuals within groups, individuals’ relative ages (juveniles <12 months old and adults >12 months old [just for SAC]), sighting distance and sighting angle were recorded.

To estimate SAC relative densities, we established 30 500-m long strip transects (width = 2 × 3.5 m) in each park. Generally, no more than 6 strip transects were located per road or track. All transects were perpendicular to the road or track, and randomly selected starting points were located on the road or track sides. All SAC latrines observed within the strip were counted independently of whether they were being used or not. Due to the large size of SAC latrines (usually 0.7 to 1.0 m^2) and because we surveyed semiarid areas with open and often short vegetation, we are confident that all the objects within the strip were counted. European hare relative densities were estimated by dividing the number of individuals observed in each transect by the length (km) of the transect. We estimated SAC and hare relative densities because in some parks the number of individuals counted was too small to use the program Distance to estimate their absolute densities (see below).

At SGNP, puma predation on SAC was studied by examining camelid carcasses and complemented by analyzing puma scats. Field necropsies of SAC carcasses were performed to determine cause of death. The presence of large tooth marks on the throat, skull or neck, and broken large bones were used as evidence of puma predation (Franklin et al. 1999).Carcasses were sexed by means of hip morphology, and aged by means of tooth wear and replacement (Raedeke 1979, Puig and Monge 1983).

At all the parks, analysis of scats was used to determine the diet of pumas because data derived solely from carcasses tend to underestimate the presence of small prey. Scats were collected opportunistically and stored in labeled paper bags; in the laboratory, scats were oven-dried at 60^{o} C and weighed; afterwards, scats were covered with water and broken up (Reynolds and Abeischer 1991). Mammalian prey were identified to the lowest possible taxonomic level on the basis of bone fragments, teeth, and hair cuticular scale and medullae characteristics (Pearson 1995, Chehebar and Martin 1989, Vazquez et al. 2000). Diet data are presented as percent frequency of occurrence (number of times an item occurred as a percentage of the total number of prey items in all scats), and as relative percent of biomass. Relative biomass of prey taken was computed estimating correction factors using the regression developed by Ackerman et al. (1984) for pumas. Correction factors were not estimated for prey weighting < 2kg. In these cases, each occurrence in a scat was assumed to be an individual and was multiplied by live weight of the prey to calculate relative biomass consumed (Ackerman et al 1984).

Data analysis

The computer program Distance 5.0 was used to calculate SAC and hare absolute density estimates (individuals/km^2). The best models were selected by choosing the lowest Akaike information criterion values (Buckland et al. 1993). We compared vicuña and guanaco densities using the program Contrast 2.0 (Hines and Sauer 1989).

For each park, relative density estimates of SAC were calculated using resampling methods. Specifically, we used bootstrap analysis to estimate mean relative densities and associated 95% CI's. We drew 30 observations (resample) randomly and with replacement from each data set and estimated the mean of this resampled set. This procedure was repeated 1000 times (iterations); resampled means were recorded each time. From this collection of means, we estimated the overall mean and 95% CI's, which where calculated by finding the 2.5th and 97.5th percentiles (Resampling Stats Inc 2006). For each park, raw data was the density of latrines found in each strip transect [SAC latrine density for each transect = number of latrines observed in the transect / transect length (0.5 km) × transect width (0.0035 km × 2)].

Among parks and among seasons (in SGNP), we analyzed differences in the diet of pumas using a χ^2 test. To compare winter puma diets among parks, we grouped prey items into four prey categories: small-sized rodents (< 500 g; Cricetidae, tuco-tucos *Ctenomys*, and Guinea pigs *Cavia*), medium-sized rodents (> 1000 g; mountain vizcacha *Lagidium viscacia*, mara *Dolichotis patagonum*), camelids (guanacos and vicuñas), and European hares. For the seasonal analysis, we grouped prey items into five prey categories: small-sized rodents (Cricetidae, tuco-tucos, and Guinea pigs), medium-sized rodents (mountain vizcacha), camelids (guanacos and vicuñas), European hares, and birds. Those categories with an overall frequency of occurrence < 5 were not used in these analyses (i.e. Dasypodidae, Equidae, unidentified rodents and mammals; birds in the among parks comparison).

We used chi square-tests and Bonferroni confidence intervals (Byers et al. 1984) to examine whether pumas consumed SAC in frequencies that differed from their seasonal availability at SGNP. Seasonal evaluation of puma consumption of SAC species was based on the number of guanaco and vicuña carcasses that presented signs of puma predation. Seasonal SAC availability was assessed based on absolute densities of guanacos and vicuñas.

We used correlation tests to explore regional (among parks) and seasonal (among seasons in SGNP) patterns between SAC and hare absolute and relative densities and their frequency of occurrence in puma scats. Such analyses were conducted using the Pearson's product-moment statistic.

Results

Absolute density estimates for vicuña, guanaco and other significant mammal species

Regional and seasonal absolute densities of guanacos and vicuñas are shown in table 1a. Vicuñas were observed only in SGNP, while guanacos were observed in all parks. Overall, vicuña densities in SGNP were larger than those of guanaco populations regardless of the park. Density of guanacos was highest at ELNP, but the large standard error of the density estimate hindered comparisons with other populations. Guanaco densities were low and similar in SGNP and LCNP. The small number of groups observed in TNP (n = 11) and SQNP (n = 6) precluded estimating absolute guanaco densities in these parks.

At SGNP, vicuña densities were similar in all seasons (χ^2= 1.89; df = 3; p = 0.59). For guanacos, the small number of groups observed and consequent large stand error of the estimator precluded any between-season statistical analysis. However, the population of guanacos appeared to increase during the spring '06. Efforts to increase sample size, therefore increasing the precision of the estimator, should help to clarify whether guanacos in this park present seasonal fluctuations in their densities.

Absolute density estimates for maras, chilla foxes, and introduced species including European hares, feral donkeys are shown in table 1b.

Carcass collection and analysis

From February '06 to February '07, we searched for SAC carcasses on a seasonal basis (tables 2 and 3). Overall, we collected 152 SAC carcasses (vicuña = 110, guanaco = 42). Twenty seven percent of vicuña carcasses and 12% of guanaco carcasses showed evidence of puma predation. Juvenile vicuña individuals (< 1 year old) represented 23% of all those vicuña carcasses that showed evidence of puma predation (n = 30); juvenile guanaco (< 1 year old) individuals represented 20% of all those guanaco carcasses that showed evidence of puma predation, although the sample size in this case was too small (n = 5). When combined with those carcasses collected in 2004, we found that (1) puma predation was the cause of death of 32% of vicuñas carcasses (n = 183) and 23% of guanaco carcasses (n = 106), and (2) juvenile vicuñas (27%) and guanacos (28%) were the age class more represented in puma kills.

Seasonal carcass information was analyzed grouping data from vicuñas and guanacos. Overall, the percentage of SAC carcasses that presented evidence of puma predation was similar across seasons [winter ‘06 = 33% (*n* = 30); spring ‘06 = 38% (*n* = 29); summer ‘07 = 30% (*n* = 17)] with one exception; during summer ‘06 only 17% of the SAC carcasses we found (*n* = 76) showed evidence of predation as the cause of death.

A summary by species, age and season of camelid carcasses collected during this (2006-07) and previous (2004) study is presented in Tables 2 and 3.

Composition of puma diet based on scat analysis: a regional and seasonal assessment

A total of 97 puma scats were collected and analyzed at SGNP, TNP, ELNP, and SQNP, LCNP during winter ‘06 (table 4). Winter frequency of occurrence of puma prey categories differed markedly among parks (χ^2= 49.1; *df* = 12; $p < 0.001$). Guanacos and vicuñas made up the bulk (68% of frequency of occurrence) of the diet of pumas at SGNP; maras, a 12-kg South American rodent, was the most frequent item found in puma scats at TNP (40%) and SQNP (44%); guanacos (32%) and Guinea pigs (21%) were the main prey items at ELNP. The small number of scats analyzed coupled with an even distribution of prey categories in puma scats precluded a similar analysis for LCNP; here, we recovered from 7 scats 8 prey items representing 8 different prey categories (table 4). In terms of relative biomass, we found that SAC made up the bulk of the diet of pumas at SGNP (89%), ELNP (72%), and LCNP (38%); conversely, exotic prey species including feral donkeys and European hares were the most important items at TNP and SQNP (table 5).

A total of 222 puma scats were collected and analyzed during four different seasons at SGNP (table 6). Our seasonal analysis of puma diet revealed that frequency of occurrence of puma prey categories differed among seasons (χ^2 = 27.6; *df* = 12; $p = 0.006$). Most notably, SAC frequency of occurrence decreased while European hare frequency of occurrence increased in spring ‘06. All remaining seasons showed similar frequencies of occurrence of prey items (χ^2 = 12.7; *df* = 8; $p = 0.11$). Overall, SAC and the mountain vizcacha, a 1.5-kg South American rodent, were the most frequent prey item in the diet of pumas at SGNP. In terms of biomass, SAC dominated by far the diet of pumas in this park (overall relative biomass = 83%; table 7).

Native and exotic prey consumption by pumas

Diet data showed that only at SGNP the prey base of pumas remained essentially undisturbed; there, 100% of the prey items found in puma scats were identified as native species (fig. 1). At LCNP, native prey species seemed to dominate the diet of pumas (but see discussion). At ELNP, native prey made up the bulk of the diet of pumas, with guanacos still playing an important role as prey, and non-native prey restricted to the consumption of European hares (tables 4 and 5). At

TNP and SQNP, native prey species were less frequent in puma scats than at SGNP, ELNP, and LCNP, but still represented the main component of the diet of pumas (fig. 1). More specifically, only at two parks, SGNP and ELNP, SAC made up the bulk of the diet of pumas.

Pumas-prey relationships: regional and seasonal patterns

When winter data from all parks were analyzed together, SAC relative densities (data from guanacos and vicuñas pooled) were positively and significantly correlated with their frequencies of occurrence in puma scats ($r = 0.951$ [95% CI: 0.435-0.996]; $t = 5.38$; $df = 3$; $p = 0.01$; $n = 5$). Conversely, no correlation was observed when SAC absolute densities and their frequencies of occurrence in puma scats were compared ($r = 0.974$ [95% CI: n/a]; $t = 4.31$; $df = 1$; $p = 0.14$; $n = 3$)(fig. 2). Similarly, hares relative ($r = - 0.28$ [95% CI: - 0.932-0.799]; $t = -0.5$; $df = 3$; $p = 0.64$; $n = 5$) and absolute densities did not show any correlation when compared to their frequencies of occurrence in puma scats ($r = 0.69$ [95% CI: n/a]; $t = 0.97$; $df = 1$; $p = 0.5$; $n = 3$) (fig. 3).

When seasonal patterns were analyzed for SGNP, neither SAC ($r = 0.568$ [95% CI: - 0.865-0.989]; $t = 0.97$; $df = 2$; $p = 0.43$; $n = 4$) nor hare ($r = - 0.954$ [95% CI: n/a]; $t = - 3.2$; $df = 1$; $p = 0.19$; $n = 3$) absolute densities showed any correlation with their frequencies of occurrence in puma scats (fig. 4). Likewise, hare relative densities were not correlated with hare frequency of occurrence in puma scats ($r = - 0.988$ [95% CI: n/a]; $t = -6.44$; $df = 1$; $p = 0.09$) (fig. 5).

Prey selection by pumas: a seasonal analysis using SAC carcasses at SGNP

We attempted to elucidate whether pumas showed some seasonal preferences when preying on SAC. Unfortunately, the number of vicuña and guanaco carcasses with evidence of puma predation that we found each season was too small to conduct reliable statistical analyses (tables 8a to 8d). A visual inspection of tables 8a to 8d suggests that pumas prey upon vicuñas and guanacos according to their seasonal availability; however, more information is needed to confidently elucidate SAC-puma relationships at a seasonal scale. When all seasons were pooled, our results showed that pumas preyed upon vicuñas and guanacos according to their availability (table 8e).

Conservation and management implications

At a regional scale, our comparative analysis showed that puma consumption of SAC was positively correlated with SAC abundances. Increasing densities of SAC resulted in an increment of SAC remains in puma scats. Such functional response has been suggested for pumas preying on guanaco populations in the Argentinean Patagonia (Novaro and Walker 2005). When each park was analyzed separately, we found that only two parks appeared to be conserving the interaction SAC-pumas: SGNP and ELNP. Conversely, SAC represented only a small portion in the diet of pumas in the remaining parks. According to the information provided by park rangers from TNP, SQNP and LCNP, SAC populations at these parks are slowly recovering. If this is true, then an increase of SAC remains in puma scats should be expected as SAC abundance increases, and at least two scenarios could be foreseen. First, an increase of SAC abundances should be correlated with an increase of their occurrence in puma scats, with SAC populations stabilizing at relatively high densities (i.e. > 8 indiv/km^2; Novaro and Walker 2005). Under this scenario, puma predation would not be a factor limiting SAC populations. Alternatively, SAC remains could increase in puma scats with SAC abundances stabilizing at relatively low densities (i.e. < 8 indiv/km^2; Novaro and Walker 2005). Under this scenario, puma predation would be responsible for limiting SAC populations. Our data on puma diet and SAC relative and absolute densities was collected over a short period of time and derives, in some cases, from small sample sizes; therefore, it cannot be used to answer whether pumas either limit or not SAC populations. However, we believe our data will be valuable to monitor trends in SAC-puma interactions in all the protected areas surveyed. In addition, quantitative information collected at SGNP and ELNP could be used to establish restoration targets in those areas where the restoration of the interaction the SAC-puma is desired.

At all parks, exotic prey species composed less than 50% of the diet of pumas. At SGNP, ELNP, and LCNP pumas consumed mainly SAC and native rodents with exotic prey species, particularly European hares, being consumed less frequently (< 16% of the total items found in scats). At TNP and SQNP, the diet of pumas was dominated by maras with exotic prey species, European hares and feral donkeys, representing < 45% of the total items found in the scats. This observation contrasts with reports from other semiarid areas of Argentina and Chile, where pumas now prey mostly on introduced lagomorphs and other exotic species (Novaro et al. 2000; Rau et al. 1991). At least in 3 out of the 5 national parks surveyed, predator-prey interactions between pumas and their native prey are being conserved, while the situation does not appear to be catastrophic in the remaining two parks. However, we acknowledge that scat sample sizes from LCNP, TNP, and SQNP are too small to draw any final conclusion. To overcome this shortcoming, we suggested park authorities to include the collection of puma scats among the activities that park rangers perform periodically. Our presence in the parks was helpful to train park rangers on scat identification and collection and we expect to increase the number of samples within the next 2 years.

We developed baseline abundance data for mammal species in all the protected areas we visited. We collected, analyzed and reported relative and absolute densities for several species of mammals including native (guanacos, vicuñas, maras, chilla fox) and exotic (European hare, feral donkey) species. For SGNP, this information was provided in a seasonal basis. This is the first time SGNP, ELNP, TNP, LCNP and SQNP are provided with such key information, considering that guanacos, vicuñas and maras are of high conservation concern (ex: some parks were created exclusively to protect SAC), and that management actions to eradicate exotic species are planned in some parks and underway in others. For instance, our data on feral donkey and SAC densities will be soon used to assess whether the eradication of donkeys at LCNP has been a successful conservation measure. Overall, we have generated quality information, which will become important conservation tools for most of the parks we surveyed and created strong ties with park rangers and managers that will allow us to continuously collaborate with the management of at least 7 reserves of northwestern Argentina.

Table 1a. - Density (individuals per km^2) estimates of vicuñas and guanacos in 4 different seasons at San Guillermo National Park and in winter 2006 at Los Cardones and El Leoncito National Parks, northwestern Argentina. Small number of observations precluded a similar analysis for Sierra de las Quijadas National Park and Talampaya National Park.

Site – Species		*n*	d_i (se)	% CV	L (k)
San Guillermo National Park					
Summer 2006					
	Vicuñas	165	11.6 (1.5)	13.1	72 (3)
	Guanacos	12	1.2 (1.3)	101.3	72 (3)
Winter 2006					
	Vicuñas	186	9.4 (0.9)	10.5	75 (3)
	Guanacos	5	0.7 (0.7)	98.9	75 (3)
Spring 2006					
	Vicuñas	214	10.5 (1.1)	10.2	94 (3)
	Guanacos	31	2.5 (1.0)	39.7	95 (3)
Summer 2007					
	Vicuñas	181	10.7 (1.2)	11.5	73 (3)
	Guanacos	10	0.8 (0.5)	59.0	73 (3)
Los Cardones National Park					
	Guanacos	29	0.9 (0.6)	68.3	156.6 (4)
El Leoncito National Park					
	Guanacos	35	5.9 (2.8)	47.8	72.4 (5)

References: ***n*** = number of observed groups; d_i = density of individuals (indiv/km^2); CV = estimated coefficient of variance; se = standard error; L = sampling effort (km); k = replicates.

Table 1b.- Density (individuals per km^2) estimates of other significant mammal species at 5 National Parks of northwestern Argentina, 2006.

Site – Species	*n*	d_i (se)	% CV	L (k)
San Guillermo NP				
European hare				
Winter 2006	15	3.4 (0.8)	23.0	83 (3)
Spring 2006	9	2.1 (1.5)	72.3	88 (3)
Summer 2007	10	2.2 (0.6)	25.8	74 (3)
Overall	34	2.5 (0.6)	23.6	246 (9)
Los Cardones NP				
European hare	41	2.8 (2.5)	90.8	95 (4)
Feral donkey	27	1.7 (0.4)	52.2	156 (4)
El Leoncito NP				
European hare	55	6.7 (3.3)	49.0	63 (4)
Sierra de las Quijadas NP				
Mara	28	3.8 (0.8)	21.3	103 (5)
Chilla fox	11	0.6 (0.2)	33.7	103 (5)
Talampaya NP				
Chilla fox	16	1.0 (0.3)	33.4	105 (5)

Table 2. - Relative age and cause of death of guanaco carcasses collected at San Guillermo National Park, northwestern Argentina, winter 2004-summer 2007 (no carcasses collected during 2005).

	Summer ‘06		Winter ‘06		Spring ‘06		Summer ‘07		Subtotal 06-07		Sub total ‘04		Total	
Age class[a]	% Puma kills	% Non-puma kills	% Puma kills	% Non-puma kills	% Puma kills	% Non-puma kills	% Puma kills	% Non-puma kills	% Puma kills	% Non-puma kills	% Puma kills	% Non-puma kills	% Puma kills	% Non-puma kills
0 to 7days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 days to 2.5 months	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	2.7	15.0	0.0	12.0	1.2
2.5 to 9 months	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	15.0	2.3	16.0	1.2
9 to 12 months	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	1.2
12 to 18 months	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	4.5	4.0	2.5
18 to 24 months	0.0	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0	0.0	0.0	2.5
24 to 36 months	0.0	21.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	5.0	4.5	4.0	7.4
36 to 48 months	0.0	5.3	0.0	14.3	0.0	0.0	0.0	0.0	0.0	5.4	5.0	13.6	4.0	9.9
48 to 72 months	0.0	15.8	0.0	14.3	0.0	14.3	0.0	50.0	0.0	18.9	15.0	25.0	12.0	22.2
72 to 108 months	50.0	10.5	0.0	28.6	0.0	28.6	100.0	50.0	60.0	21.6	5.0	9.1	16.0	14.8
108 to 132 months	0.0	10.5	0.0	0.0	0.0	28.6	0.0	0.0	0.0	10.8	5.0	9.1	4.0	9.9
132 to 156 months	25.0	5.3	0.0	0.0	0.0	14.3	0.0	0.0	20.0	5.4	10.0	2.3	12.0	3.7
156 to 168 months	0.0	5.3	0.0	14.3	0.0	14.3	0.0	0.0	0.0	8.1	5.0	0.0	4.0	3.7
Age indet.	0.0	15.8	0.0	14.3	0.0	0.0	0.0	0.0	0.0	10.8	15.0	27.3	12.0	19.8
TOTAL (N)	4	19	0.0	7	0.0	7	1	4	5	37	20	44	25	81

[a] Age categories following Puig and Monge (1983).

Table 3. - Relative age and cause of death of vicuña carcasses collected at San Guillermo National Park, northwestern Argentina, winter 2004-summer 2007 (no carcasses collected during 2005).

	Summer '06		Winter '06		Spring '06		Summer '07		Subtotal 06-07		Sub total '04		Total	
Age class[a]	% Puma kills	% Non-puma kills	% Puma kills	% Non-puma kills	% Puma kills	% Non-puma kills	% Puma kills	% Non-puma kills	% Puma kills	% Non-puma kills	% Puma kills	% Non-puma kills	% Puma kills	% Non-puma kills
0 to 7days	11.1	6.8	0.0	0.0	0.0	0.0	0.0	0.0	3.3	3.8	10.3	6.8	6.8	4.8
7 days to 2.5 months	11.1	9.1	0.0	0.0	0.0	0.0	0.0	0.0	3.3	5.0	3.4	4.5	3.4	4.8
2.5 to 9 months	22.2	9.1	30.0	23.1	0.0	7.1	0.0	22.2	16.7	12.5	13.8	13.6	15.3	12.9
9 to 12 months	0.0	2.3	0.0	0.0	0.0	7.1	0.0	0.0	0.0	2.5	3.4	0.0	1.7	1.6
12 to 18 months	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.8
18 to 24 months	0.0	9.1	10.0	15.4	0.0	14.3	0.0	11.1	3.3	11.3	10.3	2.3	6.8	8.1
24 to 36 months	22.2	4.5	0.0	0.0	12.5	14.3	33.3	11.1	13.3	6.3	10.3	4.5	11.9	5.6
36 to 48 months	0.0	2.3	40.0	7.7	0.0	0.0	33.3	0.0	16.7	2.5	3.4	22.7	10.2	9.7
48 to 72 months	11.1	25.0	0.0	46.2	25.0	7.1	0.0	11.1	10.0	23.8	13.8	11.4	11.9	19.4
72 to 108 months	11.1	13.6	0.0	7.7	0.0	28.6	0.0	11.1	3.3	15.0	3.4	9.1	3.4	12.9
108 to 132 months	0.0	9.1	10.0	0.0	12.5	7.1	0.0	11.1	6.7	7.5	13.8	11.4	10.2	8.9
132 to 156 months	11.1	0.0	0.0	0.0	12.5	7.1	0.0	0.0	6.7	1.3	0.0	0.0	3.4	0.8
156 to 168 months	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	3.3	0.0	0.0	0.0	1.7	0.0
Age indet.	0.0	6.8	10.0	0.0	37.5	7.1	0.0	22.2	13.3	7.5	13.8	13.6	13.6	9.7
TOTAL (N)	9	44	10	13	8	14	3	9	30	80	29	44	59	124

[a] Age categories following Puig and Monge (1983).

Table 4. - Composition of puma diet in five National Parks of northwestern Argentina, winter 2006. SGNP = San Guillermo National Park, TNP = Talampaya National Park, SQNP = Sierra de las Quijadas National Park, LCNP = Los Cardones National Park, ELNP = El Leoncito National Park. *Fo* = frequency of occurrence.

Prey item	SGNP		TNP		SQNP		LCNP		ELNP	
	Fo	*% Fo*	*Fo*	*% Fo*	*Fo*	*% Fo*	*Fo*	*% Fo*	*Fo*	*% Fo*
Rodents										
Cricetidae	3	6.4	0	0.0	0	0.0	1	12.5	2	5.3
Caviidae										
Dolichotis patagonum	0	0.0	4	40.0	4	44.4	0	0	1	2.6
Guinea pigs	0	0.0	0	0.0	0	0.0	1	12.5	8	21.1
Ctenomidae										
Ctenomys sp	2	4.3	0	0.0	0	0.0	1	12.5	2	5.3
Chinchillidae										
Lagidium viscacia	9	19.1	1	10.0	0	0.0	1	12.5	0	0.0
Unidentified rodent	1	2.1	0	0.0	0	0.0	0	0	3	7.9
Xenarthra										
Dasypodidae	0	0.0	0	0.0	0	0.0	1	12.5	1	2.6
Ungulates										
Camelidae[1]	32	68.1								
Lama guanicoe			1	10.0	1	11.1	1	12.5	13	34.2
Equidae[2]	0	0.0	2	20.0	2	22.2	0	0	0	0.0
Lagomorpha										
Lepus europaeus	0	0.0	1	10.0	2	22.2	1	12.5	6	15.8
Unidentified mammals	0	0.0	1	10.0	0	0.0	1	12.5	1	2.6
Birds	0	0.0	0	0.0	0	0.0	0	0	1	2.6
TOTAL ITEMS	47		10		9		8		38	
TOTAL SCATS	41		10		8		7		31	

[1] Includes guanacos and vicuñas for SGNP; only guanacos for the remaining parks.

[2] Most likely feral donkeys *Equus asinus*.

Table 5. - Estimated percentage of relative biomass of identified mammal prey consumed by pumas in 5 national parks of northwestern Argentina, winter 2006. Total number of scats analyzed is shown in table 4. SGNP = San Guillermo National Park, TNP = Talampaya National Park, SQNP = Sierra de las Quijadas National Park, LCNP = Los Cardones National Park, ELNP = El Leoncito National Park.

Prey item	Body mass (kg)	% Relative biomass consumed				
		SGNP	TNP	SQNP	LCNP	ELNP
Rodents						
Cricetidae[1,5]	0.021	0.04	0.00	0.00	0.21	0.06
Caviidae[1,5]						
Dolichotis patagonum	12	0.00	31.61	31.04	0.00	3.36
Guinea pigs[1,5]	0.225	0.00	0.00	0.00	2.20	2.55
Ctenomidae						
Ctenomys sp[1,5]	0.36	0.52	0.00	0.00	3.53	1.03
Chinchillidae						
Lagidium viscacia[1,5]	1.54	9.84	5.07	0.00	15.08	0.00
Xenarthra						
Dasypodidae[1]	2.1	0.00	0.00	0.00	20.11	2.87
Ungulates						
Camelidae[2]	55.8	89.64	12.95	12.72	38.52	72.35
Equidae[3]	132	0.00	43.46	42.68	0.00	0.00
Lagomorpha						
Lepus europaeus[4]	3.4	0.00	6.91	13.57	20.56	17.84

[1] Body masses taken from Redford and Eisenberg (1989).

[2] Body mass obtained as an average between body masses of guanacos [juveniles = 30 kg, yearlings = 80 kg, adults = 120 kg; Raedecke (1979)] and vicuñas [adults = 50 kg multiplied by a factor of 0.7 to correct for the body mass of juveniles; Redford and Eisenberg (1989), Pacheco et al. (2004)].

[3] Most likely feral donkeys Equus asinus; value represents adult body weight (250 kg) and foal body weight (14 kg) averaged.

[4] Bonino and Bustos (1994).

[5] No correction factor (see Methodology).

Table 6. - Composition of puma diet in four different seasons at San Guillermo National Park, northwestern Argentina, February 2006 to February 2007. *Fo* = frequency of occurrence.

Prey item	Summer 06		Winter 06		Spring 06		Summer 07		Overall	
	Fo	*% Fo*	*Fo*	*% Fo*	*Fo*	*% Fo*	*Fo*	*% Fo*	*Fo*	*% Fo*
Rodents										
Cricetidae	6	5.5	3	6.4	5	9.3	0	0.0	14	5.6
Caviidae	1	0.9	0	0.0	0	0.0	0	0.0	1	0.4
Ctenomidae										
Ctenomys sp	4	3.6	2	4.3	3	5.6	1	2.4	10	4.0
Chinchillidae										
Lagidium viscacia	22	20.0	9	19.1	13	24.1	10	24.4	54	21.4
Unidentified rodent	1	0.9	1	2.1	0	0.0	0	0.0	2	0.8
Ungulates										
Camelidae[1]	68	61.8	32	68.1	24	44.4	24	58.5	148	58.7
Lagomorpha										
Lepus europaeus	2	1.8	0	0.0	9	16.7	4	9.8	15	6.0
Unidentified mammals	1	0.9	0	0.0	0	0.0	0	0.0	1	0.4
Birds	4	3.6	0	0.0	0	0.0	1	2.4	5	2.0
Reptiles	1	0.9	0	0.0	0	0.0	0	0.0	1	0.4
Unidentified vertebrates	0	0.0	0	0.0	0	0.0	1	2.4	1	0.4
TOTAL ITEMS	110		47		54		41		252	
TOTAL SCATS	96		41		48		37		222	

[1] Includes guanacos and vicuñas for SGNP; only guanacos for the remaining parks.

Table 7. - Estimated percentage of relative biomass of identified mammal prey consumed by pumas in 4 different seasons at San Guillermo National Park, northwestern Argentina, February 2006 to February 2007. Total number of scats analyzed is shown in table 6.

Prey	Body mass (kg)	% Relative biomass consumed				
		Summer 06	Winter 06	Spring 06	Summer 07	Overall
Rodents						
Cricetidae[1, 4]	0.021	0.04	0.04	0.08	0.00	0.04
Caviidae[1, 4]	0.225	0.07	0.00	0.00	0.00	0.03
Ctenomidae						
Ctenomys sp[1, 4]	0.36	0.46	0.52	0.81	0.30	0.52
Chinchillidae						
Lagidium viscacia[1, 4]	1.54	11.03	9.84	14.92	13.00	11.86
Ungulates						
Camelidae[2]	55.8	87.08	89.64	70.18	79.59	83.06
Lagomorpha						
Lepus europaeus[3]	3.4	1.35	0.00	14.09	7.12	4.53

[1] Body masses taken from Redford and Eisenberg (1989).

[2] Body mass obtained as an average between body masses of guanacos [juveniles = 30 kg, yearlings = 80 kg, adults = 120 kg; Raedecke (1979)] and vicuñas [adults = 50 kg multiplied by a factor of 0.7 to correct for the body mass of juveniles; Redford and Eisenberg (1989), Pacheco et al. (2004)].

[3] Bonino and Bustos (1994).

[4] No correction factor (see Methodology).

Table 8a. - Prey selection by pumas at SGNP, northwestern Argentina, summer 2006.

	d_i[1]	Proportion total d_i (d_p)[2]	Observed (n_o)[3]	Expected (n_e)[4]	Proportion observed (p_o)	90% CI on p_o	Selected
Guanacos	1.2	0.094	4	1.2	0.308	0.021 – 0.594	No
Vicuñas	11.6	0.906	9	11.8	0.692	0.406 – 0.979	No
Total (n_t)	12.8		13				

$G_c = 2.6$, $df = 1$, $p = 0.1$

Table 8b. - Prey selection by pumas in SGNP, northwestern Argentina, winter 2006.

	d_i[1]	Proportion total d_i (d_{pi})[2]	Observed (n_o)[3]	Expected (n_e)[4]	Proportion observed (p_o)	90% CI on p_o	Selected
Guanacos	0.7	0.069	0	0.7	*Analysis not run due to the lack of guanaco samples*		
Vicuñas	9.4	0.931	10	9.3			
Total (n_t)	10.1		10				

Table 8c. - Prey selection by pumas in SGNP, northwestern Argentina, spring 2006.

	d_i[1]	Proportion total d_i (d_{pi})[2]	Observed (n_o)[3]	Expected (n_e)[4]	Proportion observed (p_o)	90% CI on p_o	Selected
Guanacos	2.5	0.195	0	1.6	*Analysis not run due to the lack of guanaco samples*		
Vicuñas	10.5	0.808	8	6.5			
Total (n_t)	13.0		8				

Table 8d. - Prey selection by pumas in SGNP, northwestern Argentina, summer 2007.

	d_i[1]	Proportion total d_i (d_{pi})[2]	Observed (n_o)[3]	Expected (n_e)[4]	Proportion observed (p_o)	90% CI on p_o	Selected
Guanacos	0.8	0.070	1	0.3	*Analysis not run due to small sample size*		
Vicuñas	10.7	0.930	3	3.7			
Total (n_t)	11.5		4				

Table 8e. - Prey selection by pumas in SGNP, northwestern Argentina, all seasons pooled 2006-2007.

	d_i[5]	Proportion total d_i (d_{pi})[2]	Observed (n_o)[3]	Expected (n_e)[4]	Proportion observed (p_o)	90% CI on p_o	Selected
Guanacos	1.3	0.110	5	3.8	0.143	0.010 – 0.275	No
Vicuñas	10.6	0.890	30	31.2	0.857	0.725 – 0.990	No
Total (n_t)	11.9		35	35			

$G_c = 0.7$, $df = 1$, $p = 0.4$

[1] d_i = denstity (indiv/km^2) from table 1; [2] proportions of d_i represent expected proportions of guanaco and vicuña carcasses preyed by pumas if each camelid species were killed in exact proportion to their availability; [3] observed numbers of guanaco and vicuña carcasses preyed by pumas; [4] estimated by multiplying $d_{pi} \times n_t$; [5] estimated, for each SAC species, as an average among all seasons. SGNP = San Guillermo National Park.

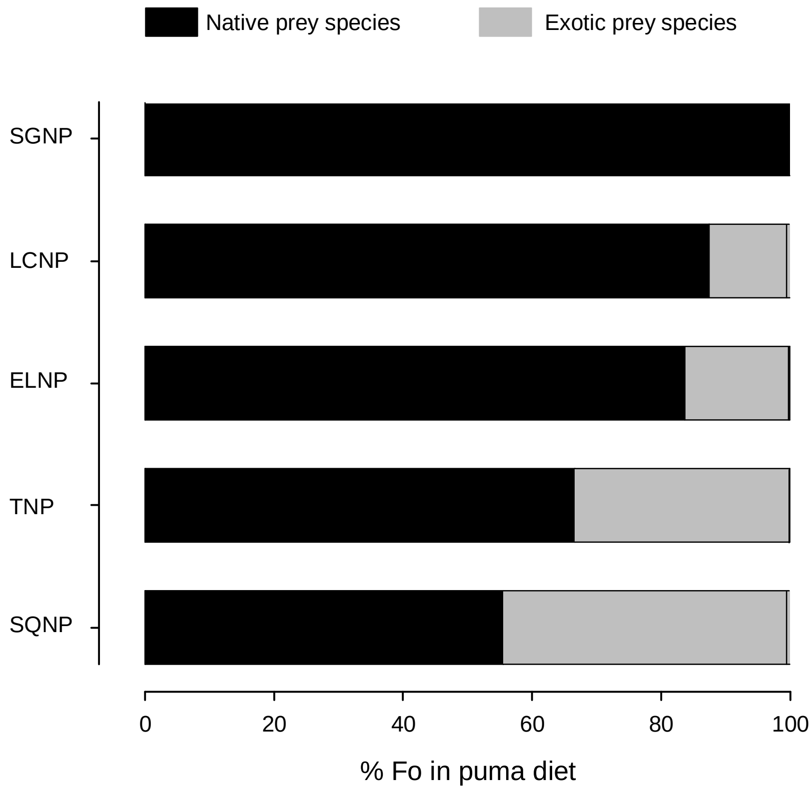


Figure 1.- Percentage frequency of occurrence (% Fo) of exotic and native prey species in puma scats at five National Parks of northwestern Argentina, winter 2006. SGNP = San Guillermo National Park, ELNP = El Leoncito National Park, LCNP = Los Cardones National Park, TNP = Talampaya National Park, and SQNP = Sierra de las Quijadas National Park. Number of scats analyzed at each park is given in table 4. Data from table 4; ***unidentified mammals*** excluded from the calculations.

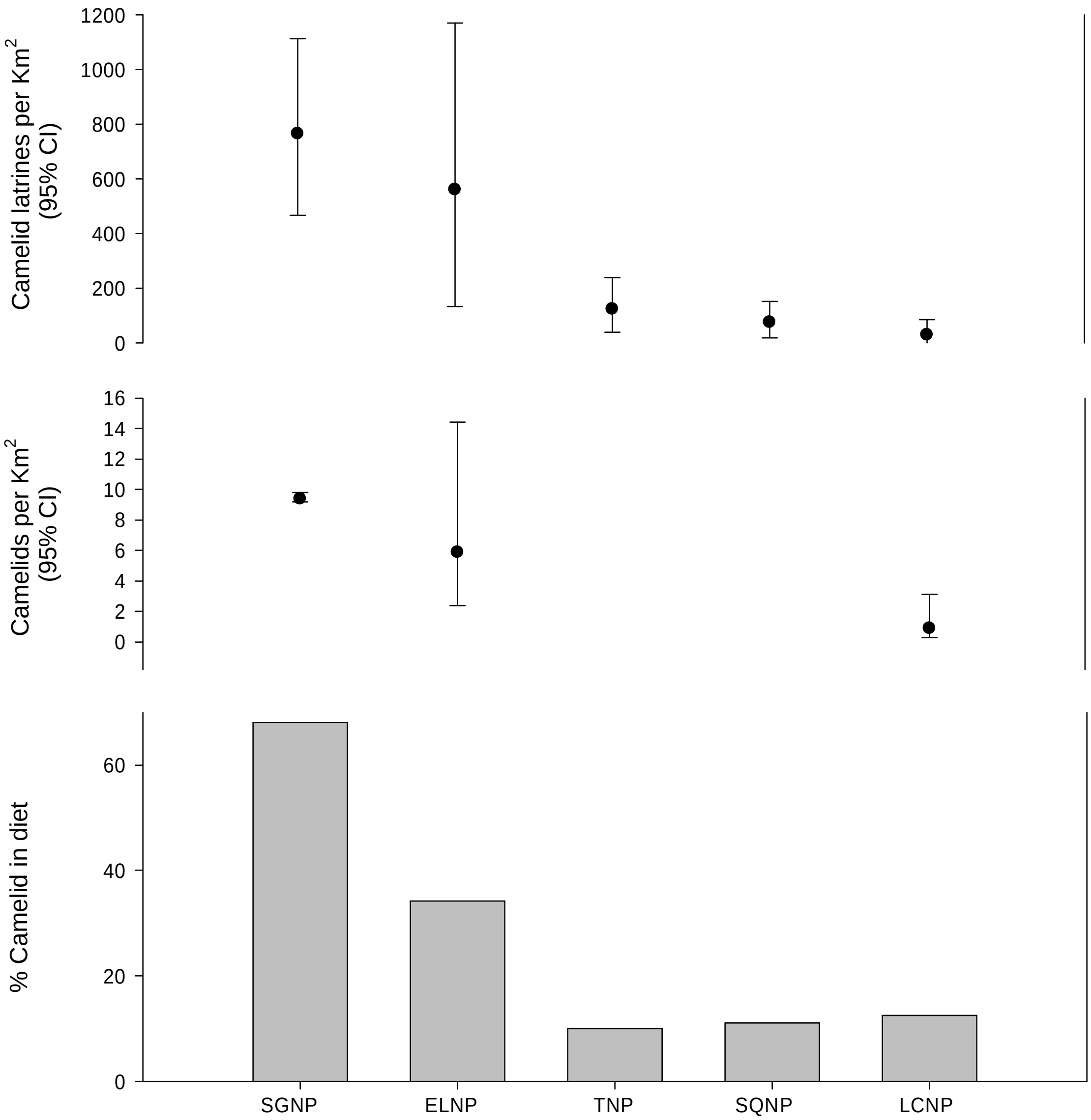


Figure 2.- Relative and absolute densities of wild South American camelids (guanacos and vicuñas) and their frequency of occurrence in the diet of pumas at five national parks in northwestern Argentina, winter 2006. SGNP = San Guillermo National Park, ELNP = El Leoncito National Park, TNP = Talampaya National Park, SQNP = Sierra de las Quijadas National Park, and LCNP = Los Cardones National Park. Thirty 500-m long strip transects (width = 2 × 3.5 m) were walked at each park (see methods) to estimate camelid latrine densities. Sample sizes for absolute density estimates and puma diet are given in tables 1a and 4, respectively.

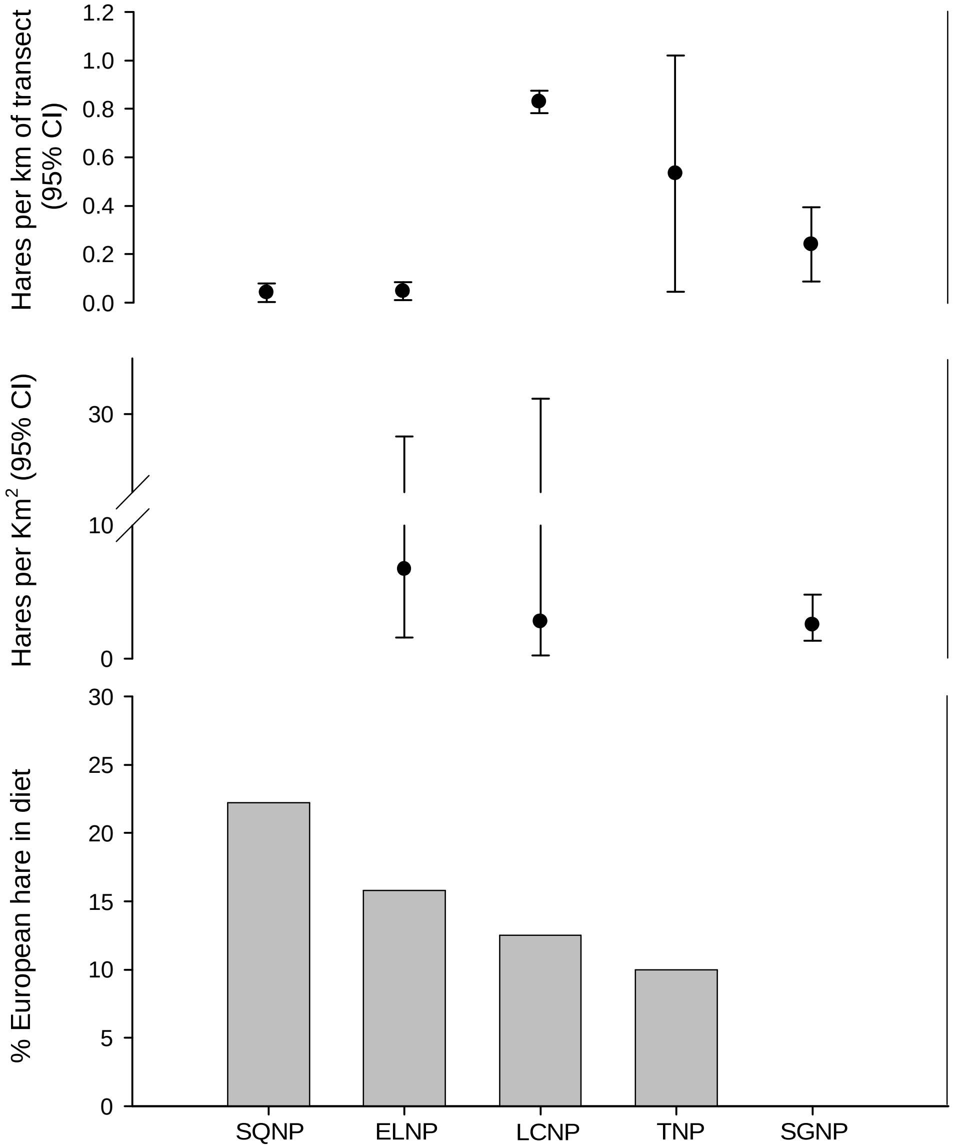


Figure 3.- Relative and absolute densities of European hares and their frequency of occurrence in the diet of pumas at five national parks in northwestern Argentina, winter 2006. SGNP = San Guillermo National Park, ELNP = El Leoncito National Park, TNP = Talampaya National Park, SQNP = Sierra de las Quijadas National Park, and LCNP = Los Cardones National Park. Sample sizes for hare absolute density estimates and puma diet are given in table 1b and table 4, respectively.

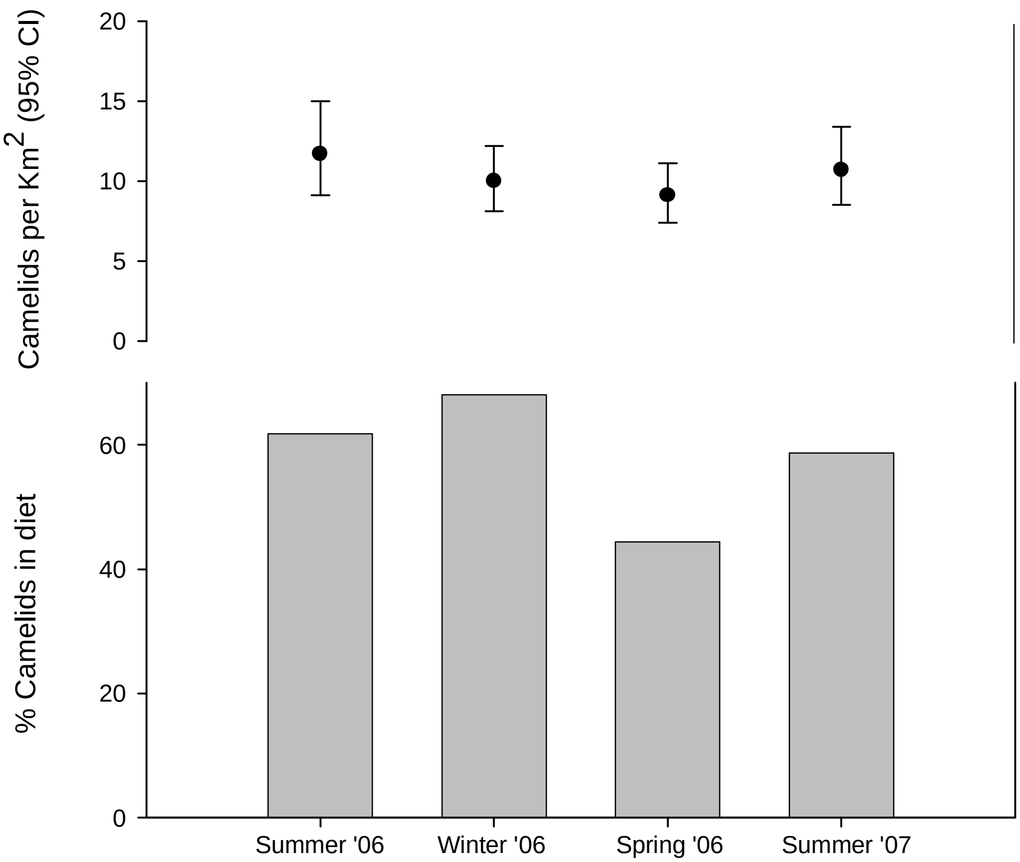


Figure 4.- Absolute densities of wild South American camelids (guanacos and vicuñas) and their frequency of occurrence in the diet of pumas during four seasons at San Guillermo National Park, northwestern Argentina. Sample sizes for absolute density estimates and puma diet are given in tables 1a and 6, respectively.

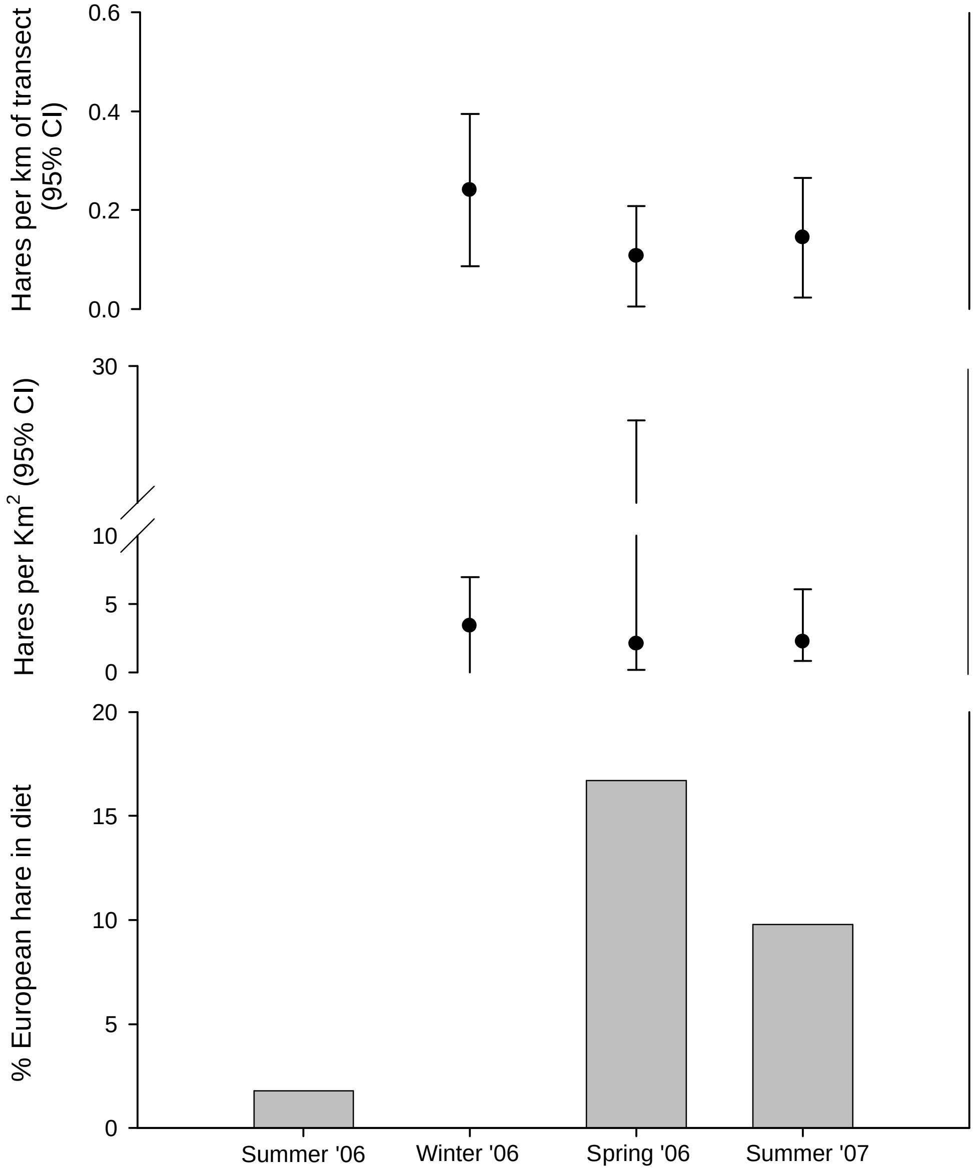


Figure 5.- Relative and absolute densities of European hares and their frequency of occurrence in the diet of pumas during four seasons at San Guillermo National Park, northwestern Argentina. Sample sizes for hare absolute density estimates and puma diet are given in table 1b and table 6, respectively. Data on hare densities not available for summer '06.

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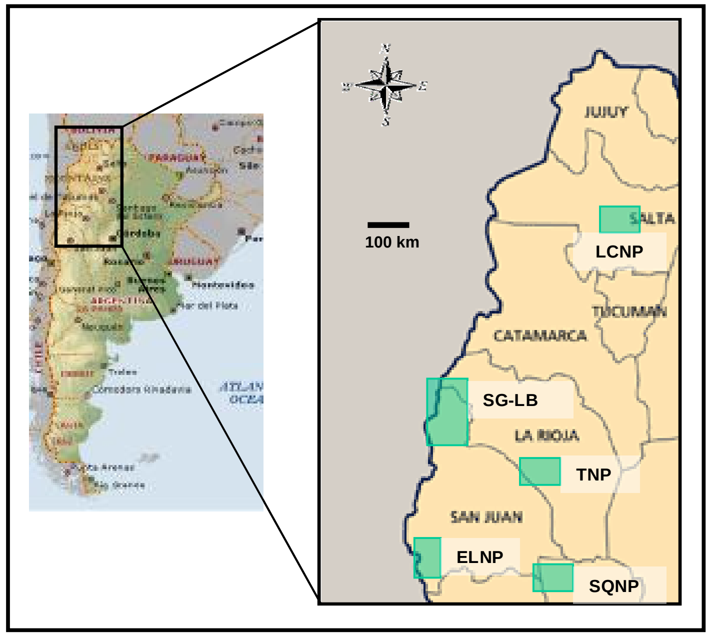
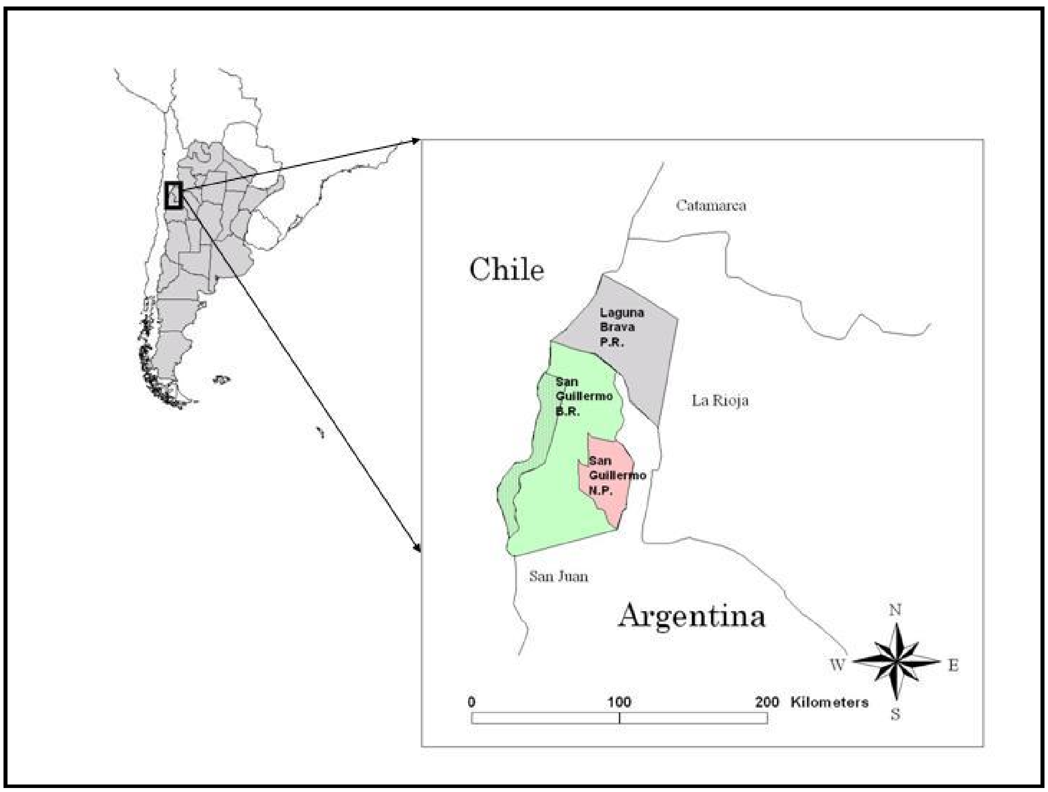
MAP 1:

Study areas – National parks and provincial reserves surveyed are shown in green (not at scale). SG-LB: San Guillermo-Laguna Brava landscape (it encompasses 3 protected areas; see map below); LCNP: Los Cardones National Park; TNP: Talampaya National Park; SQNP: Sierra de las Quijadas National Park; ELNP: El Leoncito National Park.





MAP 2:

The San Guillermo - Laguna Brava landscape – San Guillermo National Park (SGNP), San Guillermo Biosphere Reserve (SGBR) and Laguna Brava Provincial Reserve (LBPR) encompass a 1.4 million-ha area in the Andes range of Argentina. They protect intact wildlife communities that are seriously compromised in the Puna to the north, and the Patagonian steppe to the south of Argentina.

Project accomplishments (see Table A, p. 52, for a summary) and other activities and individuals associated with the project

Management and conservation: (a) This research was the first in evaluating the extent to which several reserves of northwestern Argentina protect populations of wild South American camelids (guanacos and vicuñas; SAC). Furthermore, we provided each reserve (n = 7) with quantitative baseline information, a sampling design and training that will allow park rangers monitoring SAC flight behavior responses to human activity in a continuous basis. Also, we provided a tentative threshold value (see fig. 1, p 14) that could be used in other protected and non-protected areas to evaluate the degree to which humans are – or are not – harassing SAC. This monitoring tool could be used to assess the effectiveness of management and conservation actions (i.e. increasing patrolling to deter poaching where poaching occurs) and control the potentially negative effects that increasing levels of tourism may have on SAC populations within these reserves. In fact, our data on flight responses have been included in the management and monitoring plans of SGNP. Most likely, this information will also be included in the management plan of LCNP. (b) This was the first attempt to evaluate the conservation status of a potentially key interaction between a top predator and its large ungulate prey in the Neotropics. Such effort was not focalized only in one but in several reserves. Our data on puma diet suggest that the interaction SAC-puma is not being conserved in some reserves, likely due to artificially (i.e. human-induced) small SAC populations present in those areas (TNP, SQNP and LCNP; see table 4, p 32). Because national parks are improving law enforcement and deterring poaching, we predict an increase on SAC numbers followed by an increase of SAC occurrence in puma scats; such response of pumas to increasing numbers of SAC has been reported by Iriarte et al. (1991) for Torres del Paine National Park, Chile (see references). Our research provided baseline information on SAC relative and absolute abundances, and SAC occurrence on puma scats that would allow testing the above mentioned prediction within the following 5-10 years. Along with baseline information, we also provided sampling protocols and training that allow developing of a monitoring plan for the interaction SAC-puma and SAC population trends at each reserve. Data on SAC-puma interactions and SAC abundances have been included in the management and monitoring plans of SGNP. (c) We studied the degree to which pumas relied on exotic prey species at each reserve. To do so, we evaluated puma food habits and the relative and absolute abundances of exotic prey species. Our data on exotic species abundances were the first quantitative information that was made available for all the reserves we surveyed. These estimates have now become reference values for all surveyed national parks, where the removal of exotic species has been planned (Administración de Parques Nacionales 2005[3]) or just started (Bikauskas et al. 2007[4]). Indeed, at LCNP removal of feral donkeys began shortly after we surveyed the park. Our donkey and SAC abundance estimates will be used to evaluate the effects that such management action had on populations of donkeys and SAC. To do so, we will repeat surveys in July 2008 together with LCNP staff. (d) In some parks, we provided the first density estimates for some relevant, from the conservation standpoint, species including maras, a threatened 12 kg rodent, and chilla foxes, a heavily hunted fox species. (e) Overall, all our estimates were based on sampling designs that can be easily replicated by park staff. Our work ensured that all the reserves we visited were provided with this kind of quantitative information. Managers could use this information to assess the success of future managing and conservation measures.

Training and education: During this period (Jan '06 – Feb '07), I continued training biology students and park rangers. Twelve undergraduate and graduate students from 5 different universities (4 from Argentina, 1 from USA) were involved, as volunteers, in this project. All of them received intense training in different field (transect sampling, scat collection and identification, track identification, and field necropsies) and lab techniques (transect and behavior data analysis). Some of these students will participate in the follow up of this project, which will start in December '07 and last for at least two years. Sixteen park rangers were involved in fieldwork for this project at 5 different national parks. I trained them in several field techniques, so that they continued with some field activities (i.e. scat and carcass collection) after I left the park. Names and e-mail addresses of all the personnel involved in the project is listed below.

Dissemination of results: Results of this research (fieldwork from January '06 to February '07) have been summarized in a technical report submitted to the Argentinean National Park Service and presented in public talks and seminars at the University of Wyoming (USA), National University of Buenos Aires (Argentina [Arg]; organized by the Argentinean Environmental Agency), National University of La Plata (Arg), National University del Comahue (Arg), and national University of San Juan (Arg). During these presentations, I showed the results of our work, explained the importance of conserving protected areas in northwestern Argentina, and discussed the main factors that threatened these reserves. Also, I gave presentations at each of the parks I visited; there, the audience was composed of park rangers, park managers and tourist

[3] Administracion de Parques Nacionales. 2005. Primer taller sobre el manejo de especies exóticas en la administración de parques nacionales. Unpublished report, Argentinean Nacional Park Service, 50 pp.
[4] Bikauskas et al. 2007. Experiencia de control de burros cimarrones en el Parque Nacional Los Cardones. II Congreso Latinoamericano de Parques Nacionales y otras Áreas Protegidas.

guides. So far, I have published one abstract in the Proceedings of the XXI Argentine Meeting of Mammalogy. I expect to present the remaining information of this research in professional meetings next year. I am also planning more public talks; for instance, I have been invited to give a presentation at the National University of Cordoba on November 30th. Finally, during 2008, I expect to submit at least one manuscript, based on data collected in 2006, to a peer reviewed journal.

Field technicians

During the period 2006-07, twelve undergraduate and graduate students from 5 different universities (4 from Argentina, 1 from the USA) were involved as field assistants in this project. Their names, e-mail addresses and affiliations are listed below.

- *Ana Luz Alzogaray*, e-mail: apanapalupu@yahoo.com.ar, National University of La Pampa.
- *Lina Moreno Azócar*, e-mail: ojos.sabineros@gmail.com, National University of San Juan.
- *Jodie Berg*, e-mail: not available, University of Montana.
- *Jorgelina Guido*, e-mail: jorgelinaguido@yahoo.com.ar, National University of Mar del Plata.
- *Lara Heidel*, e-mail: laraheidel@gmail.com, National University of Buenos Aires.
- *Clelia Mosto*, e-mail: clelia_mosto@yahoo.com.ar, National University of La Plata.
- *Mariel Ruiz*, e-mail: tamandua28@hotmail.com, National University of La Plata.
- *Veronica Salvador*, e-mail: verosalv28@hotmail.com, National University of La Pampa.
- *Maria J. Veinticinco*, e-mail: mariajuliaveinticinco@yahoo.com.ar, National University of La Pampa.
- *Maira Vitali*, e-mail: mairavitali@yahoo.com.ar, National University of La Plata.
- *Alvaro Wurstten*, e-mail: awurstten@yahoo.com, Wildlife Conservation Society.
- *Juan Zanon*, e-mail: juanitozanon@hotmail.com, National University of La Pampa.

Park Rangers

During the period 2006-07, sixteen park rangers from five different national parks were involved in this project. Their names and e-mail addresses are listed below.

- San Guillermo National Park, San Juan province: *Alvaro Montañez and Alejandro Carrizo*; e-mail: sanguillermo@apn.gov.ar.
- El Leoncito National Park, San Juan province: Mariana Martinez, Ana J. Sandoval, and Ceferino; e-mail: elleoncito@apn.gov.ar.
- Talampaya National Park, La Rioja province: Jose Gallo, Alejandro Nuñez, and Roberto Narváez; e-mail: talampaya@apn.gov.ar.

Ø Los Cardones National Park, Salta province: Mario Zuretti, Jose Paz, Roberto Canelo, and Marco Bulacio; e-mail: loscardones@apn.gov.ar.

Ø Sierra de las Quijadas National Park, San Luis province: Horacio Lopez, Raul O. Ocaña, Margarito Moreira, and Felix E. Pereyra; e-mail: sierradelasquijadas@apn.gov.ar.

Associated Researchers

Ø *Dr. Steven W. Buskirk*, professor at the Department of Zoology and Physiology UWYO, e-mail: marten@uwyo.edu. Dr. Buskirk is Emiliano's main advisor; as such, he has been involved in the sampling design, data analysis, and fundraising for this project.

Ø *Dr. Andrés Novaro*, Wildlife Conservation Society-Argentina, e-mail: anovaro@wcs.org. Dr. Novaro has been involved in all the aspects related to this project since the beginning; he has already obtained major funding that will be used to continue this research.

Ø *Jonathan Pauli MS*, PhD candidate at the Department of Zoology and Physiology UWYO, e-mail: jpauli@uwyo.edu. Mr. Pauli has been involved in data analyses.

Dissemination of results (both grants)

First grant (fieldwork: June 2004 – June 2005)

Peer reviewed articles

- **Donadio E**. and S.W. Buskirk. 2006. Flight behavior in guanacos and vicuñas in areas of western Argentina with and without poaching. *Biological Conservation* 127 (2): 139-145.
- **Donadio E.**, M.J. Bolgeri and A. Wurstten. In press. First quantitative data on the food habits of the Mountain Caracara. *Journal of Raptor Research* 41(4): 000.
- **Donadio E.,** M.L. Merino and M.J. Bolgeri. Submitted. The effect of exotic prey on the trophic ecology of two coexisting owls in the southern Neotropics. *Journal of Raptor Research*.

Presentations in professional meetings

- **Donadio E.**, A.J. Novaro, M.C. Funes, R. Palacios, A. Wurstten, M.J. Bolgeri, M. Vitali and R. Batistella. 2006. Puma (*Puma concolor*) prey selection patterns in the high planes of northwestern Argentina (in Spanish). Proceedings of the Argentinean Meeting of Ecology, Córdoba, Argentina.
- Wurstten A., M.J. Bolgeri, R. Palacios, M. Vitali, R. Batistella and **E. Donadio**. 2006. The diet of the Andean caracara (*Polyborus megalopterus*, Aves, Phalconiformes) in the high planes of northwestern Argentina (in Spanish). Proceedings of the Argentinean Meeting of Ecology, Córdoba, Argentina.

- **Donadio E.** and S.W. Buskirk. 2005. A comparison of the trophic relationships among three predator species in areas with abundant native prey and depleted of native prey in southern South America. Proceedings of the Wyoming Wildlife Society Meeting, Jackson Hole, Wyoming, USA.
- **Donadio E.**, A.J. Novaro, S.W. Buskirk, R. Palacios, M.J. Bolgeri, A. Wurstten, M. Vitali and R. Battistella. 2005. Trophic relationships among pumas (*Puma concolor*) and chilla (*Pseudalopex griseus*) and culpeo foxes (*P. culpaeus*) in the high planes of northwestern Argentina (in Spanish). Proceedings of the XX Argentine Meeting of the Theriological Society, Buenos Aires, Argentina.
- Bolgeri M.J., **E. Donadio** and M. Merino. 2005. Notes on the diet of the ñacurutu (*Bubo virginianus*) in the high planes of northwestern Argentina (in Spanish). Proceedings of the XI Argentine Meeting of Ornithology, Buenos Aires, Argentina.

Seminars

- Title: Camelids on the run: the unbelievable and sad story of poached guanacos and vicuñas in the Argentinean Andes. Seminars at the Department of Zoology and Physiology, UWYO, November 2004 and School of Natural Sciences, Universidad Nacional de La Plata, Argentina, July 2005.

Final Report

- **Donadio E.** 2005. Mortality factors affecting sympatric populations of guanacos and vicuñas in the vulnerable Andean puna, Argentina. Report presented to the Argentine National Parks Agency, Denver Zoological Foundation, Lincoln Park Zoo, Idea Wild and Rufford Small Grants, 48 pp.

Additional Reports

- **Donadio E.**, M.J. Bolgeri and A. Wurstten. 2006. Diet of the Mountain caracara (*Polyborus megalopterus*), the Great Horned owl (*Bubo virginianus*) and the Barn owl (*Tyto alba*) in the San Guillermo – Laguna Brava landscape (In Spanish). Report to the Argentine National Parks Agency, 15 pp.
- Wurstten A., A.J. Novaro, A. Carrizo, A. Montañés and **E. Donadio**. 2006. Flight behavior of South American camelids in San Guillermo National Park and Laguna Brava and San Guillermo provincial reserves (march-may 2005) (In Spanish). Report to the Argentine National Parks Agency, 9 pp.
- **Donadio E.**, A.J. Novaro, A. Carrizo, A. Montañés and H. de la Fuente. 2006. Trophic relationships among pumas (*Puma concolor*) and chilla (*Pseudalopex griseus*) and culpeo foxes (*P. culpaeus*) in the San Guillermo-Laguna Brava landscape and the potential for

exploitative competition with the Andean cat (*Orailerus jacobita*) (In Spanish). Report to the Argentine National Parks Agency, 9 pp.

Second grant (fieldwork: January 2006 – February 2007)

Presentations in professional meetings

- **Donadio E.**, M.S. Vitali, A. Wurstten, A.J. Novaro and S.W. Buskirk. 2007. Flight behavior of wild South American camelids in seven protected areas of northwestern Argentina (in Spanish). Proceedings of the XXI Argentine Meeting of the Theriological Society, Tafi del Valle, Argentina.

Public talks (combining information gathered in 2004-2005 and 2006-2007)

- Title: The struggle to conserve semiarid landscapes in northwestern Argentina: a long road to Utopia. Public talk at the University of Wyoming, April 2007.
- Title: The ecological importance of conserving protected areas of northwestern Argentina. Public talks at Universidad Nacional de Buenos Aires (organized by the Argentinean Agency of Environment [June 2007]), Universidad Nacional de La Plata (June 2007), Universidad Nacional del Comahue (September 2007), Universidad Nacional de San Juan (October 2007), Los Cardones National Park, Sierra de las Quijadas National Park, El Leoncito National Park, and Argentinean Park Service – Northwestern Office (city of Salta, Salta province).

Main Report

- **Donadio E.** 2007. The impact of puma predation and human harassment on two species of threatened wild South American camelids: a regional and seasonal assessment in protected areas of north western Argentina. Report presented to the Argentine National Parks Agency, Denver Zoological Foundation, and Rufford Small Grants, 53 pp.

Expense Report

Total awarded by the RSG Foundation (period January 2006-February 2007): £ 3,500.00. I had budgeted ₤ 1,200 for gas for the vehicle, ₤ 1,400 for food in the field, ₤ 400 for vehicle maintenance, ₤ 250 for camping supplies and equipment, and ₤ 250 to buy a spotting scope. I spent the money as I had planned with one exception; because the Wildlife Conservation Society lent us a spotting scope, it was not necessary to buy it. Consequently, I used ₤ 250 to partially cover housing expenses.

Table A. – Summary of project accomplishments [the table shows a minimum since full potential of data gathered from 2006 to 2007 has still to be developed].

Field work period	Total funding from RSG (£)	Final Report Submitted	Pictures submitted	Number of undergraduate and graduate students involved and trained	Number of park rangers involved and trained	Number of reserves surveyed	Public talks/ seminars presented	Abstracts in professional meetings			Publications in peer reviewed journals		
								Presented	Accepted	In prep.	Published/ Accepted	Submitted	In prep.
June to August 2004	2,200	Sep. '05	Y	5	3	3	6	5	n/a	n/a	2	1	1
January '06 to February '07	3,500	Oct. '07	Y	12	16	5	5[4]		1	4			1
Total	**8,000**			**15[1]**	**17[2]**	**7[3]**	**11**	**5**	**1**	**4**	**2**	**1**	**2**

[1] Two students participated in both fieldwork periods; [2] Two park rangers participated in both fieldwork periods; [3] One reserve (San Guillermo National Park surveyed during both projects); [4] Combining results of both fieldwork periods.

Acknowledgments

During the period January 2006 February 2007 the following undergraduate and graduate students assisted with data collection in the field: Ana Luz Alzogaray, Lina Moreno Azócar, Jodie Berg, Jorgelina Guido, Lara Heidel, Clelia Mosto, Mariel Ruiz, Veronica Salvador, Maria J. Veinticinco, Maira Vitali, Alvaro Wurstten and Juan Zanon. Sixteen park rangers provided field assistance while we were surveying the parks where they had been assigned: SGNP: A. Montañez and A. Carrizo; TNP: Jose Gallo, Alejandro Nuñez and Roberto Narvaez; LCNP: Mario Zuretti, Jose Paz, Roberto Canelo and Marco Bulacio; SQNP: Horacio Lopez, Raul O. Ocaña, Margarito Moreira and Felix E. Pereyra; ELNP: Mariana Martinez, Ana J. Sandoval and Ceferino. We thank the Rufford Small Grants 2nd grant, Denver Zoological Foundation, Wildlife Conservation Society and Idea Wild for funding this project. Permission to conduct this research was granted by the Dirección Nacional de Parques Nacionales Delegación Centro (SGNP, ELNP, TNP, SQNP) and Delegacion Noroeste (LCNP). E.D. was partially supported by WCS.