Rufford Small Grant for Nature Conservation

Guanaco vulnerability to puma predation: ecological factors affecting antipredator responses

Pregnant female at C2BPR
Photograph by Alejo Irigoyen

Final Report

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Figure 1. Argentina is located in South America, between the Andes Mountains to the west and the southern Atlantic Ocean to the east and south.

Grant Recipient Details

Grant Recipient Details	
Your name	Andrea Marino
Project title	Guanaco vulnerability to puma predation: ecological factors affecting antipredator responses
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Introduction

Guanacos *(Lama guanicoe)* are the dominant large herbivores of South American grasslands, playing a fundamental role in ecosystem structure and functioning, therefore they are critical as an umbrella species for conservation efforts. However, their populations have been drastically reduced and fragmented during the last century. Interspecific competition with sheep, hunting and land degradation were identified as major factors in the decline in guanaco numbers, currently representing only 2-9% of the original population. On the other hand, pumas *(Puma concolor)* have recently recolonised much of their former range, exploiting the abundant supply of introduced prey. Puma predation seems to be preventing the recovery of guanaco populations at some sites, even after the removal of sheep and the relief from interspecific competition. Thus, puma predation is an additional threat to be addressed if we aim to recover guanaco populations as a key component of conservation plans for the Patagonian steppe. Individual behaviour, social organization and habitat structure are major factors determining prey vulnerability to predation. Parasite load and nutritional status directly affect individual behaviour and are often linked to predation outcomes. After the release from predation, some behavioural patterns persist in prey populations while others disappear, and their phenotypic plasticity varies from one species to another. In fact, relaxed predation pressure after predator eradication can result in the loss of antipredator behaviour,

increasing prey vulnerability to possible carnivore re-colonisations. However, there is no information about these processes within guanaco-puma systems. The aim of this project was to address guanaco behavioural plasticity as well as to identify the ecological factors that could limit antipredator responses, increasing guanaco vulnerability to puma predation.

Since this project started, in October 2007, we have conducted 29 field surveys and spent more than 160 days in the field, at some of the most significant protected areas for guanacos in Patagonia.

Study sites

Figure 2. Study locations

San Pablo de Valdés (SPV)

San Pablo de Valdés (SPV) wildlife reserve is a research station at Península Valdés, which is one of the most important natural protected areas of Argentina and was declared World Natural Heritage Site by the UN. San Pablo is managed by a local NGO, Fundación Vida Silvestre Argentina (FVSA). It is located on the coast of Nuevo Gulf (42°43' S; 64°15' W). The area of SPV is 7360 hectares, comprising a mosaic of typical srublands and grasslands of coastal Patagonia. Srublands are characterized by *Chuquiraga sp.*, main grasses are *Stipa sp* and *Poa sp*., and *Sporobolus rigens* and *Hyalis argentea* dominate sandy soils (Codesido, Beeskow et al. 2005). Average annual rainfall is 240 mm, occurring mostly during autumn-winter months, and mean seasonal temperature ranges from 8°C in winter to 18°C in summer. Soon after sheep removal, guanaco density was less than 4 guanacos/km^2 (during 2006) but this number has increased to 11.46 (2009) during this study. Puma are historically scarce at Península Valdés and there have been no reports of puma presence in San Pablo. Thus we considered this site as a null-level in terms of puma predation pressure.

La Esperanza-SOMU (LE-SOMU)

La Esperanza Wildlife Refuge, is a privately owned 6700 ha protected area located in the coast of the San Matías Gulf (42°7' S; 64°57' W), in Chubut Province. The vegetation is characteristic of the Southern Monte, but sharing plant species with the Patagonian Province in the coastal area (León et al., 1998). The Monte Phytogeographic Province is characterised by a tall shrubland covering 40-60% of the soil surface. Whereas, ground cover in the Patagonian Province varies from 35 to 65 %, but may increase substantially in rainy periods when annual plants contribute a high proportion of the

total cover (Beeskow, Elissalde et al. 1995). The creosote bushes *Larrea nitida* and *L. Divaricata* dominates the western side of the ranch where the Monte prevails across the higher plains, whereas the quilimbay *Chuquiraga avellanedae* dominates the cliffs and canyons towards the coastal steppe. The most abundant grasses are *Stipa tenuis* and *Poa ligularis*. The southern neighbouring farm belongs to SOMU (Fishery Workers Union), and was included in our guanaco surveys. Its habitat features are similar to those of La Esperanza coastal steppe and pumas move across both ranches. Average annual rainfall across the area is 200 mm, occurring mostly during autumn-winter months.
Formerly a ranch devoted to sheep ranching until the year 2000, La Esperanza was purchased by a local non-government organization, Fundación Patagonia Natural. Sheep were reduced in numbers and ranching activities restricted to one 1500 ha paddock next to the main building. Guanaco density is about 8 animals.km-2, and puma predation was the main cause of mortality between 2002 and 2004 accounting for up to 40% of the dead guanacos (Baldi, unpublished data).

Cabo Dos Bahías Provincial Reserve (C2BPR)

Cabo Dos Bahías Provincial Reserve is a small protected area (1700 hectares) located in south-eastern Chubut (44° 55' S; 65° 31'W). The vegetation is characteristic of the Patagonian Province and composed by shrubs, as *Chuquiraga avellanedae, Lycium chilense, Mulinum spinosum* y *Nassauvia spp.* and grasses, as *Stipa tenuis* y *Poa ligularis* (Beeskow, Del Valle et al. 1987). As for the previous sites, most of the precipitation occurs during autumn-winter months (Barros and Rivero 1982) and the annual average for the area is 250 mm (Beeskow *et al.*, 1987). Mean annual temperature is 12,8 ºC, 4-6 ºC in July and 18-21 ºC in January. During this study, guanaco densities ranged from 47 to 60 individuals/km^2. There have been no guanaco predators reported in the area for more than 20 years.

Monte León National Park (MLNP)

Monte León was the first National Park located on the Patagonian coast, in Santa Cruz Province (50° 06'S; 68° 54'W). It comprises 60.000 hectares of grasslands and shrublands. Grasslands are characterized by *Junellia tridens* and *Lepidophyllum cupressiforme* whereas shrublands are characterised by *Festuca pallescens Puccinellia sp., Agrostis sp.* and *Poa atropidiformis* (Oliva, Humano et al. 2006). Average annual precipitation is 240 mm, occurring mostly during winter months, and mean seasonal temperature varies from 1ºC in winter to 20ºC in summer. Guanaco densities during this study varied from 12 to 21 individuals/km^2, with evidence of seasonal movements between altitudinal strata. Pumas are common in the area, and puma predation is the main cause of guanaco mortality (data obtained during this study), accounting for 40% of biomass of pumas diet (Travaini and Zanón Martínez 2008).

La Payunia Provincial Reserve (PPR)

The study was conducted in the north-eastern section of La Payunia Reserve (36°10' S, 68°50' W), a 442,996 hectares protected natural area in northern Patagonia, Province of Mendoza (Berg 2007). The xerophyllous vegetation is a Patagonian shrub steppe. Moderate vegetation cover (58%) is shrubby interspersed by grasses; dominant species include: *Neosparton aphyllum*, *Chuquiraga erinacea*, *Larrea divaricata*, *Cassia aphila*, *Panicum urvilleanum*, *Poa spp.*, and *Stipa spp* (Puig et al., 1997). Annual precipitation averages 255mm, occurring mostly during the summer months, and mean seasonal temperatures range from 6°C in winter to 20°C in summer (Puig, Videla & Cona, 1997). Guanaco local density at this section of the reserve was 35 individuals/km^2 during this study. Pumas are abundant in the area and guanacos are a major item in their diet (Berg 2007).

Level of achievement of the project's original objectives

Next section enumerates the specific objectives and the unforeseen difficulties that arose while this project was carried out.

Objective 1

The first objective was to address guanaco behaviour plasticity at individual level in terms of antipredator response. To achieve this objective, we conducted focal observations of individuals from populations exposed to contrasting predation rates (C2BPR vs. MLNP). In order to account for differences in risk perception and behavioural plasticity, we compared individual vigilance and time allocation to foraging activities, as well as the corresponding group size effects, between populations. This objective was fully achieved. Although, fortunately, sample sizes were larger than expected (more than 300 focal observations) and extra data is still waiting for analysis.

Objective 2

The second objective was to assess the role of puma predation and habitat structure in shaping guanaco social organization, trying to identify possible factors that could limit guanaco's antipredator response. The proposed activities to accomplish this objective were population surveys to estimate local abundance and social variables, across the five protected areas with contrasting ecological conditions. This objective was fully achieved after conducting 17 population surveys, and satellite images processed for each studied site. Imagery data was used to estimate the phenological cycle and primary productivity of each site during an 18-month period.

One unforeseen difficulty faced at this point was that the people supposed to provide satellite imagery data for this project did not do it. After several months I had to gather the data by other means. First, I collected information on vegetation communities for 4 of the five study sites, from unpublished studies. For the fifth site, I used plant community descriptions available in published papers (the corresponding source of information for each site is mentioned in the site description section at the beginning of this report). At the same time, I learned how to download and process MODIS satellite images using free access recourses available in the web. Even though this difficulty has delayed the rest of my work for about two months, it was worthwhile because, instead of having one-point estimate of productivity for each site as expected, I was able to assemble index time series for each site. These series provided invaluable information about key factors affecting guanaco spatial and temporal distribution.

Objective 3

The third objective was to evaluate guanaco age and sex categories killed by pumas, to correlate with parasite load and nutritional state. Also, to describe killing sites at different scales and assess the relative predation risk associated to different habitat types. This objective was partially achieved because we could find only one carcass fresh enough to take proper samples during the study, precluding statistical analysis of parasite loads and nutritional state. However, we found 45 carcasses, and 26 allowed to study sex and age class selection by pumas, and killing sites characterization in MLNP. The assistance provided by MLNP rangers to collect dead guanacos during the periods that we were not at the park made possible to accomplish this objective.

Objective 4

The fourth objective was to study the ecological correlates of parasite activity in terms of guanaco social organization by using a non invasive method. We had planned to take faecal pellets and samples from guanaco carcasses from each population studied. As well as for Objective 3, this was partially achieved because of the small number of fresh carcasses found. On the other hand, for two of the populations guanaco densities were so low at the beginning of the study that it turn out to be impossible to take enough faecal samples representative of the population.

Another proiect on guanaco health was already being conducted at Payunia Reserve when I started this study, developed by the Parasitology Lab from Veterinary Faculty, Universidad Nacional de Buenos Aires and Universidad Nacional del Litoral. These staff are specialists in free-ranging guanaco parasites. We did not take faecal samples at La Payunia to reduce overlap and increase efficiency working in collaboration, as our colleagues agreed to provide the data for this site and at the same time increase their sample after analysing HPG and OPG from faecal samples collected in Cabo Dos Bahías reserve and Monte León National Park during this study, enhancing the quality of our results considerably.

Objective 5

The fifth objective was to estimate some critical population parameters for guanacos at different density levels and puma predation pressure. This objective was fully achieved. We estimated the fawn/female ratio for each population, which with additional data from future surveys will be modelled to understand the role of ecological variables on fertility rate and ultimately on population growth. In addition, we described major mortality sources for the MLNP guanaco population, and their relative contribution to the overall mortality rate.

Three most important outcomes

The three most important outcomes of this study to date are described in the following section.

Guanaco Behavioural plasticity

Preliminary data analysis shows that guanaco time allocation differs between contrasting predation risk levels. Guanacos tend to be more vigilant and spend less time in foraging activities when they are exposed to a high rate of puma predation, compared to a population free from predation. Moreover, the decrease in individual vigilance as group size increases, known as group size effect and which is the typical antipredator response, is evident under predation risk but absent in the predator free population. These results indicate that guanacos reduce their antipredator response in absence of predators. Future studies are required to know if after released from predation, they can still recognize pumas as predators or how long they need to be exposed to them to restore their antipredator response.

Behavioural Correlates of parasite activity

Coccidiosis was one of the intestinal diseases with greater prevalence in both populations studied. Our results shows that 1) ML has a grater prevalence of coccidiosis than cabo 2 bahías, 2) both populations have a greater proportion of infected individuals during summer than during autumn, and that 3) a greater proportion of alfa males than females are infected, and the bachelor males are the individuals that shows lower prevalence.

When modelling the number of oocysits per gram of feces (OPG), as an indicator of parasite activity, we found that most of the variation (55%) was between individuals from different age classes within the same group, and between groups at the same site (33%). Finally, we found that in large groups (>6 adults), individuals had higher OPGS than in smaller groups. This last result was observed for

Nematodirus sp. egg counts (HPG) as well. Unfortunately, complex data structure precluded prevalence analysis for this group of parasites. These results are not only the first behavioural correlates of parasite activity for free ranging guanacos but also resulted in evidence of the cost of living in groups.

Modelling social organization

Our results indicate that predation, local density and vegetation structure are major factors determining guanaco family group size. Family groups are larger where exposed to high rates of puma predation than at predator-free sites. Groups are larger in grasslands than in shrublands as well. Finally, we found a positive relationship between group size and local density.

On the other hand, we modelled population distribution between the main social units: family groups and non territorial groups (only male groups and mixed groups). Our results indicate that primary productivity and timing of the vegetation phenological cycle are key factors determining the distribution of the population between these social units. We found a greater proportion of the population in family groups where the overlap between the vegetation senescence season and the mating season was higher, and the productivity was lower. This greater proportion of the population found in family groups in the former sites is probably related to almost all the females distributed among these social units and non territorial groups composed exclusively by males, in contrast with the large non-territorial mixed groups found in more productive areas.

Based on these results, a general hypothesis to predict guanaco relative vulnerability to puma predation can be “those populations situated in areas where vegetation senescence occurs during the summer, which tend to be relatively poor shrublands, should be more vulnerable to puma predation, than those situated in areas where the greening season occurs in summer”. The underlying arguments for this idea result from the combination of current results and previous theory to describe guanaco population at summer-dry sites:

1. A greater proportion of the population is within family groups, which tend to be smaller than other social units, and markedly territorial, increasing their vulnerability through reduced detection ability, highly predictable location and increased potential encounter rate with predators. In addition, family group sex ratio (1 adult male + 5-8 females) can increase female relative exposure to predation, amplifying potential consequences over population growth rates.
2. Group sizes tend to be relatively smaller in shrublands than in grasslands, limiting antipredator benefits arising from grouping.
3. Populations at low productivity areas tend to occur at relatively lower densities reducing group size as well, thus limiting grouping antipredator benefits.

4. Shrublands favour puma hunting strategy through increased vegetation cover to stalk its prey and approach close enough without being detected (Hornocker 1970; Bank and Franklin 1998). This fact was supported by killing sites characterization during this study.
5. These populations tend to be sedentary and territorial all year round so there is no period of release from territorial predators as could be in migratory populations.

According to these hypotheses, testable predictions can be derived in order to address actual vulnerability to puma predation in these scenarios.

Involvement of local communities

Local communities have benefited from this project mainly indirectly, throughout improved interaction between us and corresponding local authorities/managers.

Monte León National Park

During this project we taught park rangers how to conduct population surveys of guanacos and other herbivores using *DISTANCE Sampling*, as well as an introduction to distance data analysis. Monte León rangers are capable now of surveying their guanaco population and they will probably be able to analyse the data to obtain reliable abundance estimates by themselves in the near future. This training has allowed them to survey herbivore populations at neighbouring ranches too, improving their relationships with local farmers who tend to see the park as a threat for sheep ranching since guanacos and pumas are abundant. Well trained rangers play a crucial role in promoting alternative use of guanacos in neighbouring ranches as a complementarty activity to traditional sheep ranching.
This project has also provided the first data on guanaco diet composition for the area, allowing the Park administrators to adjust the available methodology for estimating herbivore carrying capacity which has been originally developed for sheep.

Cabo Dos Bahías Protected Area

C2BPR is a small protected area that holds the highest density population of guanacos. This area has failed to support a stable guanaco population without marked demographic cycles, stressing the importance of the delicate balance in predator-prey systems, and the consequences of contrasting management practices adjacent to the reserve. Because they are so habituated to human presence, this is probably one of the sites with a greater potential to study and admire guanacos in the world. Thank to this project, we have started to work directly with the local authorities, both the Protected Areas and Fauna and Flora Provincial Agency defining the baseline for a management plan for the

reserve and neighbouring ranches, trying to find the best way to deal with this complex problem. Active participation of local authorities has enhanced our interactions and, as well as in MLNP, we have had the opportunity to transfer our experience on population surveys by training government officers and providing technical advice in a very dynamic way.

San Pablo de Valdés Field Station

FVSA, through the station Director Andrés Johnson, has secured funding to survey guanaco population at the reserve site for a three-year period, continuing the monitoring programme that we started with this project.

Penínisula Valdés Protected Area

Finally, we are currently assisting the staff of Protected Areas Local Agency in writing the first proposal for monitoring Península Valdés guanaco population as part of a government programme, conducted and supported by the corresponding agency.

I think that one of the key unplanned effects derived from this project has been to transfer the capability to monitor guanaco populations to the local authorities and administrators, rather than depending on the availability of scientific projects which are often short–term and unpredictable to ensure a sustained effort in population monitoring.

Students training

Besides rangers and wardens, during the sampling period we have trained 5 undergraduate students and 5 volunteers in population surveys, whose help has been invaluable. One of them, Laura Lamuedra, is now actively working with us on puma-guanaco interactions, and gaining experience in her first research project.

Plans for the future...

In addition to finishing my PhD instruction, the plan for the future is not only to test predictions derived from current results but to try to continue the monitoring programmes as well, accounting for vital ecological variables as resource dynamics, predation and pathogens, and gathering proper time series to understand how these factors shape guanaco population dynamics.

Sharing the results with others

Besides the corresponding reports to local authorities and NGOs involved in this project, these results will be shared with the local community through the open meetings that the Centro Nacional Patagónico organizes periodically. To share these results with the scientific community I will try to make public major findings through academic meetings and scientific journals.

Timescale

RSGF grant was used during a 17 months period, which was approximately the anticipated length of the field work. Although I thought that data processing and analysis would have been finished almost at the same time than the field work, it took longer than expected.

Budget

In the following table all figures are in £ sterling, using an exchange rate of 1£ sterling= 6.18 pesos argentinos. The major difference relies on the fact that the trailer used at C2BPR by researchers in previous years was not longer available and we had to rent one at the same cost as tourists. At the same time, MLNP administration restored park buildings for researchers to stay in better conditions in exchange of domestic utensils for the houses. This unplanned expenditure was responsible for the bulk of the difference in the Subsistence Item. Fortunately, this effect was compensated by savings in fuel expenses due to the very efficient vehicle rented at CENPAT research centre. (The official document written by MLNP authorities expressing thanks to the RSGF for its donation is attached to this report).

Item	Budgeted Amount	Actual Amount	Difference
Food, batteries and subsistence in the field	1139.03	1659.11	-520.08
Fuel	837.52	587.77	249.75
Bus tickets, vehicle cannon and transport	1340.03	1111.53	228.5
Office and lab supplies, sample transport	502.51	549.84	-47.33
Total	3819.09	3908.24	-89.15

Important next steps

The important next steps, after finishing extra data analysis and reinforcing the main conclusions, are to elaborate the base line of a future project to understand how the ecological factors identified during this study actually affect guanaco numbers in time, to provide essential information needed to plan sustainable use programmes. Understanding population dynamics and demographic processes will be decisive in the near future as the political pressure to exploit the remaining guanaco populations is increasing and official culling programmes are imminent.

Use of the RSGF logo in materials produced in relation to this project

Although I have highlighted the RSGF support in every site we have worked, I have not been able to use the logo because I have not done any presentation yet. However, as we have now our first results to present, is my intention to use the logo and to give the corresponding credits to the RSGF.

Collaborators

The following persons have been directly involved in this project:

Parasitological Analysis were conducted by Vet María Virginia Rago, Vet Marcela Uhart and Vet student Valeria Colombo, from the Global Health Program- Wildlife Conservation Society, Dr. Pablo Beldoménico from the Facultad de Ciencias Veterinarias de la Universidad del Litoral, Esperanza. Santa Fe, and Dr. Carlos Blanco from Facultad de Ciencias Veterinarias. Universidad de Buenos Aires. (UBA).

Marcela Nabte provided logistical support in *Distance* and carcasses surveys and Laura Lamuedra provided assistance in *Distance* and carcasses surveys, and mortality data analysis.

Victoria Rodriguez and Gustavo Pazos conducted vegetation censuses and provided general assessment on vegetation dynamics.

María José Bolgeri provided logistical support and assessment at La Payunia Reserve.

Phd supervisors: Dr. Ricardo Baldi and Dr. Andrés Novaro.

Acknowledgements

I would like to thank to the RSG for the financial support that made possible this study, and to WCS for providing optical equipment through Ricardo Baldi projects. This study would not be possible without the aid of all the people that helped in the field work. I want to thank in particular: Alejo Irigoyen, Marcela Nabte, Laura Lamuedra, Victoria Rodriguez, Gustavo Pazos, Martín Zamero, Ivan Tolaba, Nicolás Sueiro, Florencia Siri and Martín del Brío, and to María José Bolgeri who has made possible for me to conduct surveys at La Payunia. Also I want to thank the staff of Monte León National Park, specially to Lorena Martinez, Mariana Martínez and Pablo Rosso, and rangers and volunteers at La Esperanza and Cabo Dos Bahías, Jonathan Jones and Soledad Diaz Ovejero from Chubut Protected Areas Department, Marcia Flores and Paula Castro from Chubut Flora and Fauna Department, and Ricardo Amoroso from CENPAT for his technical advice. I want to thank specially to Andrés Johnson from FVSA, who has provided logistical help to work at San Pablo and invaluable guidelines and support to conduct the entire project.

I agree to this report being published on the Rufford Small Grants website

Lic. Andrea Marino

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