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Density and habitat use at different spatial scales of a guanaco population (*Lama guanicoe*) in the Monte desert of Argentina

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Abstract

The first density estimates of a peripheral guanaco population and its habitat use at different spatial scales are presented for a protected area of Monte desert, Argentina. Transects were surveyed in the wet and dry seasons of 2005. All guanaco herds observed during systematic surveys using roads and tracks were GPS located and their habitat use was identified. Herd size differed significantly between the dry and wet seasons. Population densities differed between wet (0.10–0.12 individuals/km^2) and dry seasons (0.60–0.75 individuals/km^2). The population estimates ranged from 75 individuals (dry season) to 388 individuals (wet season). Guanacos showed differential habitat use, the first determinant being abiotic factors, such as topography, soil characteristics or microclimate conditions, animals being detected in rougher rocky substrata in the dry season and in open flat terrain in the wet season, followed by a mesoscale selection defined by plant communities. At the latter scale, guanaco preferentially used mixed creosote bushland and saltbush more intensively during the wet season, and open scrub and columnar-cactus slopes in the dry season. The estimated population of this protected area was small but its population density was within the range of other populations and was relatively high for this dry and unproductive area.

Keywords: arid environments; conservation; population estimates; protected areas; ungulates.

Introduction

Knowledge of the status of small populations of wild mammals and their main ecological needs is fundamental to taking proper conservation decisions (Groom et al. 2006). Density and total population estimations are associated with the likelihood of population persistence and characterization of habitat use helps to identify the key elements of the territory upon which they rely. With regard to habitat use, it is important to note that it is determined not only by biotic factors such as food resources (Senft et al. 1987) or predation risk (Lima 2002, Creel et al. 2005) but also by abiotic factors such as topography and water availability, which frequently become determinants of broad-scale distribution patterns (Bailey et al. 1996). As a result, some kind of spatial hierarchy in habitat use can be detected for many animal species (Senft et al. 1987, Kotliar and Wiens 1990, Turner et al. 1997) and management of protected areas should be the focus of attention.

The guanaco (*Lama guanicoe*, Müller 1776) is the largest of the wild South American camelids and it is distributed from 8°S in Perú to almost 55°S on Navarino island (Chile). Within this range it has been encountered from sea level to 4600 m (Puig 1995). Towards the end of the 19th century, guanaco populations were present in nearly all Argentinean biomes, occupying open, scrub-dominated areas and open woodlands. Currently, guanacos are abundant only on the Patagonian steppes and in the Andean foothills (Cunazza et al. 1995). The causes of this decline have not been well documented but they can include hunting, competition with domestic livestock and/or exotic herbivores, and loss or fragmentation of habitat resulting from agricultural development (Cunazza et al. 1995). Even so, there still remains some relict, isolated populations in restricted areas, generally within scarcely altered habitats in north-central Argentina (Sosa and Sarasola 2005). Among these, very little is known about the guanaco populations of the Monte desert biome, a temperate dry desert where guanacos depend for food on woody plants and cacti, as herbaceous plants are scarce (Acebes et al. unpublished data).

This study presents the first density and population estimates from the arid extreme of the species' distribution within Argentina, in one of the most arid areas of South America. It also provides the first published data on seasonal habitat use by guanacos at plant community (mesoscale) and landscape spatial scales.

Materials and methods

Study area

The study was carried out in Ischigualasto Provincial Park (29°55′ S, 68°05′ W) in San Juan Province, Argentina (Figure 1) which, together with Talampaya National Park, con-

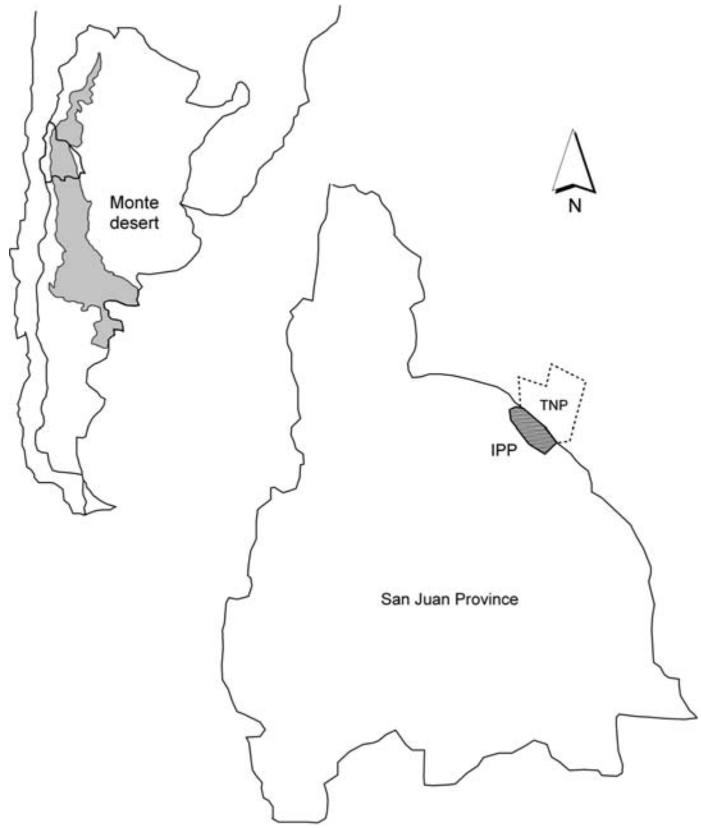

Figure 1 Location of Ischigualasto Provincial Park (IPP) in San Juan Province, Talampaya National Park (TNP) and the Monte desert biome (Argentina).

stitutes the Ischigualasto-Talampaya World Heritage Site (UNESCO). The park extends over 60,369 ha at a mean altitude of 1300 m a.s.l. The climate is typical desert, with a mean annual temperature below 18°C (range -10°C to +45°C) and a mean temperature over 22°C during the hottest month. Mean annual precipitation ranges from 80 to 140 mm, concentrated during late spring and summer (November–February).

The Monte is the dominant biome of the protected area (Márquez et al. 2005). The vegetation is dominated by species of the families Zygophyllaceae (*Larrea* spp., *Zuccagnia punctata*, *Bulnesia retama* and *Plectrocarpa tetracantha*), Fabaceae (*Prosopis* spp., *Cercidium praecox*, *Geoffroea decorticans*, *Senna aphylla*, *Ramorinoa girolae*), and Chenopodiacae (*Atriplex* spp. and *Suaeda divaricata*). Cacti (*Trichocereus* spp., *Tephrocactus* spp. and *Opuntia sulphurea*) and Bromeliads (*Deuterocohnia longipetala* and *Tillansia* spp.) are also abundant, but to a lesser extent. The average plant cover is low, less than 30%, with a seasonal and sparse herbaceous layer (Acebes et al. unpublished data).

Density estimates

Guanaco population density was evaluated from a total of six 5-km transects during each of the late wet (March–April) and dry (August–September) seasons of 2005. The starting points and directions of transects were randomly chosen, with the proviso that they should not overlap. Transects were walked by two observers with binoculars and were registered with a GPS. We recorded the distance (by laser telemeter) and bearing (by precision compass) from the transect line of different herds or individuals detected, as well as date and time, habitat and herd size. Density estimates were determined with the DISTANCE 5.0 program (Thomas et al. 2005). To evaluate the accuracy of our population estimates with DISTANCE, we calculated the number of individuals per km^2 using all the sightings within a 500-m strip to each side of the transect line, as recommended for large ungulates in open habitats (Caughley 1977). To achieve this purpose, we reprojected all the sightings and determined the 500-m buffer zone around the transect track with GIS software (ARCGIS 9.2, ESRI, USA).

Habitat use

To determine whether guanaco followed the hierarchical patterns of resources selection described for ungulates (Senft et al. 1987), habitat use was analyzed at two different spatial scales: a mesoscale defined by plant communities and a landscape scale taken to be the different geological units found in the protected area. We have used geological units as a proxy for abiotic factors such as soil characteristics, topography, and particular microclimatic conditions or water availability, whereas plant communities represented food availability.

Table 1 Description of plant communities that were recorded on guanaco sightings.

Plant community	Description
Mesquite woods	*Prosopis chilensis* formations associated with seasonal rivers
Creosote bushland	*Larrea cuneifolia* monospecific formations
Open Creosote bushland	*L. cuneifolia* with sparse plant cover (5–10%)
Mixed Creosote bushland	*L. cuneifolia*, *Zuccagnia punctata*, and other woody species
Columnar-cactus slopes	Formations dominated by columnar cactus (*Trichocereus terscheckii*)
Dense scrub	Community of woody shrubs with a higher plant cover (20–40%)
Mixed scrub	Similar to dense scrub but with lower plant cover (5–10%)
Saltbush	Communities dominated by *Atriplex lampa* and/or *A. spegazzinii* (5–10%)
Open scrub	Formations with very low plant cover, dominated by *Plectrocarpa tetracantha*
Barrens	Areas with practically no vegetation (0–5% cover)

In addition to the transect data, we noted and georeferenced (using GPS) all records of guanaco herds (n=75 sightings) made during systematic daily surveys along the tourist route and along roads and secondary tracks within the park. The sampling effort was equivalent during wet and dry seasons and totaled 150 survey hours (approximately 40 km/day over 50 days). This sampling scheme was designed to address the low number of guanaco sightings made per day. Some groups might have been detected on more than one occasion. The plant communities given in Table 1 were noted when assigning guanaco sightings to habitat. These plant communities were used as a proxy for habitat on account of their variability in species composition, vegetation cover, and structure.

Comparisons of the number of sightings in different habitats were done by employing the Monte Carlo CHITEST (Romesburg and Marshall 1985). To overcome problems arising from the assumption of minimum expected frequencies, this software generates random tables (n=9999) with the same distribution of rows and columns as the original data. Seasonal differences in herd sizes were evaluated with a Mann-Whitney U-test (Zar 1998).

All guanaco observations were projected using GIS software into a Landsat 7 ETM+ satellite image (30 m resolution) previously classified by geological criteria (Chuvieco 2002) and were then assigned to the geological units of the study area. The three geological units where guanaco observations were located varied in topography as well as in soil composition and structure. The Ischigualasto unit is an open and relatively flat expanse of fine-textured Triassic silts where vegetation is scarce or absent, the Los Rastros unit comprises rocky hillsides of consolidated Triassic sandstones with abrupt relief, and finally the Quaternary sediments are almost flat areas of coluvial deposits. Differences between seasons in guanaco sightings on these geological units were analyzed with the Monte Carlo CHITEST.

Results

Density estimates

Transect distances totaled 30 km in both seasons, with very few sightings. Density estimates using DISTANCE varied between seasons: wet season, 0.60 individuals/km^2 (CV=91.93%); dry season, 0.12 individuals/km^2 (CV=0.0%); both seasons combined, 0.38 individuals/km^2 (CV=134.23%). The alternative estimation method, i.e., the 1-km wide belt transect, yielded similar results: 0.75 individuals/km^2 in the wet season and 0.10 individuals/km^2 in the dry season. The Park population is therefore estimated to range from 388 individuals in the wet season to 75 in the dry season.

Habitat use

On the systematic daily surveys we recorded 35 guanaco sightings in the wet season and 40 guanaco sightings in the dry season. Herd size differed significantly between the seasons (mean±SD: wet 4.86±4.08, dry 6.70±3.56; Mann-Whitney U-test: U=456, p=0.009).

Habitat use at a landscape scale also differed between seasons (χ^2=20.645, df=2, p<0.0001). Most wet season guanaco observations were in the Quaternary sediments unit, whereas the Los Rastros unit was the most used by guanacos in the dry season (Figure 2).

Guanaco habitat use at plant community scale also differed between the wet and the dry seasons (χ^2=38.915, df=9, p<0.0001). Mixed Creosote bushland and Saltbush were the most used in the wet season and open and mixed scrub and Columnar-cactus slopes were most used in the dry season (Figure 3).

Discussion

These results show that the guanaco density in this protected area of the Monte desert is comparable to that of other important populations in Argentina (see below), despite its aridity and low plant cover. The low total numbers estimated makes the population potentially vulnerable to human pressure and other threats, particularly in view of the seasonal displacement of the guanacos and their potential dependence on unprotected sites outside the reserve.

Density estimates

Density estimates obtained from DISTANCE and the transect method were very similar despite the number of guanaco observations being lower than that recommended to yield robust results using DISTANCE (Buckland et al. 2001). The

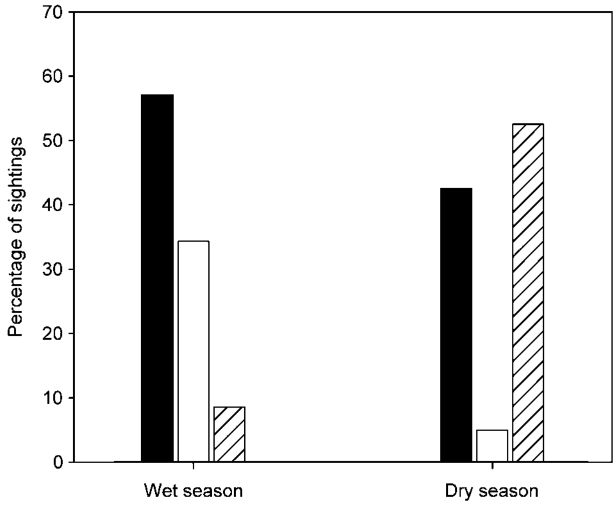

Figure 2 Guanaco habitat use at landscape scale between seasons. Black bars correspond to Quaternary sediments, white bars to Ischigualasto unit, and striped bars to Los Rastros unit.

range of densities is lower than those encountered in the San Guillermo Biosphere Reserve in Argentina (1.46 individuals/km^2, Puig and Videla 2007), relatively close to Ischigualasto Provincial Park but within the Puna and High-Andean biome. In other parts of the country, such as the Valdés Peninsula (Chubut), densities are within the range of the protected sector in the Patagonian biome (0.59 individuals/km^2) but lower than in the unprotected zones of the Monte biome (1.09 individuals/km^2). Censuses by other authors (Amaya et al. 2001) reveal guanaco densities similar to those in Ischigualasto Provincial Park (Chubut: 0.39 individuals/km^2; Río Negro: 0.26 individuals/km^2; Neuquén: 0.52 individuals/km^2). The guanacos in the Patagonian steppe zones of Tierra del Fuego occur at lower densities (0.98 individuals/km^2, Bonino and Fernández 1994; 0.52 individuals/km^2, Montes et al. 2000)

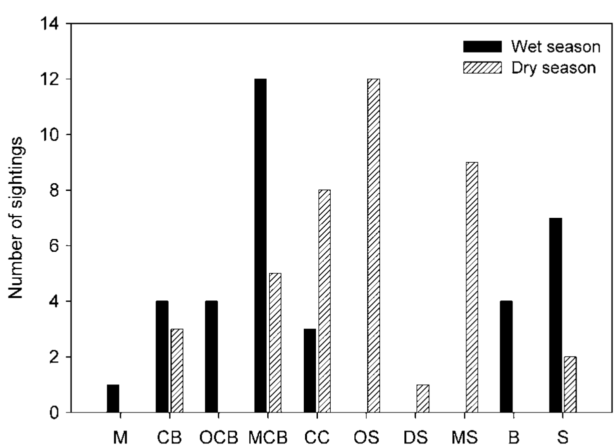

Figure 3 Number of guanaco sightings by plant communities: Mesquite woods (M), Creosote bushland (CB), Open Creosote bushland (OCB), Mixed Creosote bushland (MCB), Columnar-cactus slopes (CC), Open scrub (OS), Dense scrub (DS), Mixed scrub (MS), Barrens (B), and Saltbush (S).

than those of the Woodland/Steppe ecotone (1.72 individuals/km^2, Bonino and Fernández 1994; 2.13 individuals/km^2, Montes et al. 2000) but always at higher densities than those in Ischigualasto Provincial Park. The density estimate for Ischigualasto Provincial Park falls within the range of other populations but seems relatively high for such a dry and unproductive area, which might be due to the refuge effect of this protected area relative to its surroundings (Malo et al. 2007). The estimated maximum of around 400 individuals is within the range of published minimum sizes for viable populations (Caughley and Sinclair 1994).

With regard to seasonal variation in herd size, our results are in accordance with other studies that have established that family herds tend to be larger in winter than in summer (Puig 1995). Herd sizes fall within the range described for other guanaco populations (6.6 individuals, Tierra del Fuego; Bonino and Fernández 1994), being larger than those in the Catamarca Andes (3.5 individuals; Lucherini 1996) and only slightly smaller than those in the San Juan Puna (8.36 individuals; Puig and Videla 2007), Argentine Patagonia (7.2 individuals; Gader and del Valle 1982) and the Chilean sector of Tierra del Fuego (7.5 individuals; Raedeke 1978). Differences in density estimates between seasons can result from short-distance movements during the dry season to the most productive zones, which comprise the western sector of the protected area and its surrounding mountains. Indeed, intra-annual variation in numbers is much less than that described for other populations (Ortega and Franklin 1995, Contreras et al. 2006) and is very similar to that of the isolated populations in north-central Argentina (Sosa and Sarasola 2005).

Habitat use

Comparisons of sightings between plant communities/geological units were feasible because guanacos were readily detectable, so that their relative habitat preferences could be adequately described. The large size of guanacos assured their detectability and both the geological units and plant communities were sufficiently open to offer good visibility from the tourist route, roads and secondary tracks from where the surveys were made.

Large-scale movements of ungulates might be driven by the need to find new water sources or to avoid adverse climatic conditions. Microsite characteristics, such as the presence or absence of wind, affect where animals rest or graze (Bailey et al. 1996). During the wet season guanacos preferred geological units such as Ischigualasto and Quaternary sediments characterized by open and flat topography. Puig et al. (2008) found the same pattern of habitat use by guanacos in northern Patagonia. However, during the dry season guanacos were mostly seen on the Rastros geological unit and secondarily on Quaternary sediments. The Rastros unit consists of stony hillsides full of gullies which generate their own microclimates and provide refuges for the guanacos, as has been described for the Patagonian populations (de Lamo et al. 1998). In contrast, the flatter areas with very low plant cover remain exposed to the strong cold winds of the area.

The mesoscale approach seemed to confirm the pattern described above. Habitats with low plant cover, such as saltbush and mixed creosote bushland located in the central and driest part of the study area, are generally flat and offer good visibility, and they were used by guanacos mainly during the wet season. Guanaco herds include newborns at this time and they probably favor open zones that allow potential predators to be detected more readily (Bank et al. 2003). Although sparse, plants are sprouting there at this season and are a source of food. Thus, during the wet season, guanacos probably face a trade-off between predation risk and trophic needs, as has been described for other ungulates (McCullough 1999, Creel et al. 2005). During the dry season, however, the guanaco mainly move to more peripheral areas with low to medium plant cover, such as open and mixed scrub, as well as the Columnar-cactus slopes. This might be because they seek green plants and water, the latter being a limiting resource during this period and found in very few locations in the park. The ability to modify their diet in response to trophic availability extends to eating cacti, as has been described from other hyperarid zones in South America, such as the Atacama desert (Raedeke and Simonetti 1988). Small patches of dense scrub were clearly avoided by guanacos in the wet season and were occasionally used in the dry period. Predators such as puma (*Puma concolor*, Linnaeus 1771) could use these patches for concealment, as has been described in other ungulate studies (Kie 1999).

In conclusion, these results also raise certain questions of great interest regarding the conservation of the guanaco population of the Monte desert biome. Population density was in the range of other populations but its small size makes it fundamental that there should be interconnectivity with some adjacent populations such as that of Talampaya National Park. However, in this latter protected area, data resulting from three randomly chosen 5-km transects, which detected no guanacos, and from systematic surveys along the tourist routes and other roads of the park, which detected only two guanaco herds in distant locations, suggest a density and total number of guanacos considerably lower than in Ischigualasto Provincial Park. Therefore, the survival of this interesting population, located at the arid extreme of the species distribution within Argentina and in one of the most arid areas of South America, might not be guaranteed unless proper measures are carried out and such conservation efforts should be targeted at the full set of habitats used by the species during the course of the year.

Acknowledgements

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