



Original article

Low habitat overlap at landscape scale between wild camelids and feral donkeys in the Chilean desert



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ABSTRACT

Feral domestic ungulates may compete with the populations of wild herbivores with which they coexist, particularly so in arid regions. The potential competition between wild camelids and feral donkeys at the eastern sector of the Atacama Desert is evaluated in terms of their coincidence or segregation in habitat use and complemented with a comparison of reproductive output (yearling/adult ratio) of vicuña family groups in the proximity vs. distant from donkey observations. Habitat use of wild camelids and donkeys was sampled driving some 1250 km of roads and tracks at the dry and wet seasons. There were 221 vicuñas (*Vicugna vicugna*) sightings, 77 for donkeys (*Equus asinus*), 25 for guanacos (*Lama guanicoe*) and 8 for hybrids between guanacos and domestic llamas (*Lama glama*), as well as 174 randomly selected control locations. By means of Generalised Discriminant Analysis and Analysis of Variance we show that all ungulates actively select their habitat, with significant differences between use and availability in the area. Donkeys are relatively abundant in comparison with camelids and coincide broadly with both of them across the altitudinal gradient, but they fall between them in local scale habitat selection and do not seem to force their displacement from their preferred habitats. Thus donkeys occur preferentially on slopes with a high cover of tall shrubs, whereas vicuñas use valley bottoms with grass and guanacos the upper slope zones with grass. The potential for competition between donkeys and wild camelids is thus limited and it does not affect the reproductive output of vicuña in this region. Therefore, with the present knowledge we suggest that population control is not currently merited for feral donkeys.

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1. Introduction

The spread of alien species as an outcome of human activities and their naturalisation in ecosystems is regarded as one of the greatest threats to biodiversity. Such introduced species may alter the ecosystems through such processes as competition, predation, the spread of disease or the alteration of the physical environment (Meffe and Carroll, 1997; Primack, 1998). As a result, some native species may decline, sometimes to the extent of local or global extinction. The first species to disappear are frequently specialists and those that occur at low population densities (Davies et al., 2004). A cascade of effects is frequently set in train afterwards via

networks of interspecific interactions, with a variety of often poorly predictable collateral consequences (Traveset and Richardson, 2006). By this means diverse ecosystems see the replacement of indigenous species by those that are more tolerant of human activities, leading towards the biotic homogeneity that is currently one of the principal concerns of conservation biology (Olden et al., 2004; Olden, 2006).

The raising of grazing livestock is among the human-led processes that most modify ecosystems, on account of its extent and the variety of the effects generated. In the first instance, the primary objective of livestock introduction is to channel primary productivity towards human consumption, which invariably involves the occupation of the habitats of wild herbivores and a reduction of the resources available to the latter (Bagchi et al., 2004; Suryawanshi et al., 2010). Furthermore, there are deliberate human influences on livestock-grazed ecosystems that may modify

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vegetation to facilitate grazing (e.g. use of fire) and that may involve predator control or the forced displacement of wild herbivores from their preferred habitats in order to minimize competition (Michalski et al., 2006; Kissui, 2008).

Arid and semi-arid zones represent an extreme case of the use of ecosystems for extensive livestock raising and of potential for competition between native and exotic ungulates. Given the lack of water, such ecosystems are only exploitable for agriculture or intensive livestock raising in the vicinity of the few rivers and they are most frequently exploited for low-density grazing over extensive areas. However, the scarcity of resources also has an impact on wild herbivore populations, increasing the likelihood of adverse effects of competition with domestic herbivores (du Toit and Cumming, 1999, see however Homewood et al., 2001). This circumstance is exacerbated by the interannual variability of rainfall and availability of forage, given that herders will do their best to feed and water their animals when resources are scarce. As a result, the wild herbivore populations of arid zones may suffer greater deprivation during scarcity periods and may display fluctuations in abundance that are greater than those characteristic of their natural population dynamics (Marshal et al., 2008). The establishment of feral populations of livestock species is another collateral effect of extensive grazing in arid zones, arising from the minimal management of livestock and because such feral populations may represent a supplementary resource to humans during periods of scarcity.

The donkey is a paradigmatic animal in this context within the ecosystems of arid zones, but little is known about its effects on wild herbivores and their shared ecosystem. The donkey is a native of arid regions from Africa that has successfully colonised the American and Australian deserts following its introduction there by humans as a pack animal. It was introduced to the Americas in the 16th century and seems to have become established in the wild during the 19th century (McKnight, 1958; Grinder et al., 2006). From the human perspective, the donkey is indispensable as a pack animal in many arid regions and it is often the preferred choice given its resistance to adversity, its low forage requirements and its tolerance of water shortage (Smith and Pearson, 2005). In addition, its feral populations are often exploited by local people, both as a source of pack animals and for food in times of need (Attum and Mahmoud, 2012). The ecological effects of these donkeys are not well known but they may compete with other herbivores for food, water and shade (Choquenot, 1991; Marshal et al., 2008; Suryawanshi et al., 2010; Attum and Mahmoud, 2012), transmit parasites (Ferede et al., 2010) or damage vegetation (Abella, 2008; Malo et al., 2011). However, in some cases the donkeys show sufficient habitat segregation from native herbivores for the possibility of interspecific competition to be discarded (Marshal et al., 2012).

Populations of feral donkeys are relatively frequent in the deserts and semi-deserts of South America, from lowlands up to altitudes of nearly 4000 m (Iriarte, 2007), although they have received little attention. They coexist with wild camelids: the guanaco *Lama guanicoe* and the vicuña *Vicugna vicugna*, with which they may compete for food (Borgnia et al., 2008; Reus et al. 2014; Wursten et al., 2014). The principal guanaco populations are on the steppes of Patagonia and Tierra del Fuego, and there are only small and fluctuating populations in desert areas (Baldi et al., 2008). Some of these latter occur at such low densities as to promote hybridisation with their domestic congener, the llama *Lama glama* (Kadwell et al., 2001). The vicuña, in contrast, inhabits semi-desert regions above 3700 m where it depends on montane meadows and swampy habitats -vegas (Franklin, 2011). The vicuña was in danger of extinction in the 1960s but its populations on the northern Chilean altiplano have increased and now they fluctuate in relation to plant productivity and other local environmental

conditions (Lichtenstein et al., 2008; Shaw et al., 2012). Poaching and competition with livestock are regarded as significant threats to both species despite they are listed as of Least Concern by IUCN (Baldi et al., 2008; Lichtenstein et al., 2008). There are few studies offering parallel data on feral donkeys and camelids and all of them have been from areas where donkeys are scarce. Such studies note that donkeys may compete with camelids for food but that they show some degree of difference in habitat selection at the landscape scale (Ovejero et al., 2011; Acebes et al., 2012).

In this context our principal objective is to evaluate potential competition between feral donkeys and wild camelids in desert and semi-desert areas of the Atacama Desert by examining their overlap or segregation in habitat use at the landscape scale. It is expected that both donkeys and wild herbivores will coincide within the most productive habitats, given the low productivity of the region, and in the areas of coincidence it is expected that wild herbivores will shift towards less preferred habitats where their fitness could be reduced. Conversely, if habitat selection by donkeys and wild camelids was very different, competition for resources due to habitat overlap could not arise and negative effects on fitness would not be expected. As secondary objectives of the paper we present data on abundance and habitat selection by donkeys and guanaco/llama hybrids in a South American desert, given the existing lack of such information.

2. Methods

2.1. Study area

The study area embraces all land above 2500 m a.s.l. in the Tarapacá region, Chile, an area of approximately 1,680,790 ha. Tarapacá is in the heart of the Atacama Desert, with areas in which precipitation is virtually absent and too unpredictable to allow the establishment of ungulate populations. Nevertheless, the altiplano and pre-cordillera areas here receive annual rains of 10–200 mm derived from humid tropical air that crosses the Andes during the Austral summer (Moreira-Muñoz, 2011). As a result there are herb and shrub formations on the hillsides and also plant communities dependent on humidity in the valley bottoms (Luebert and Pliscoff, 2006). Endangered populations of vicuñas and guanacos inhabit these ecosystems (Baldi et al., 2008; Lichtenstein et al., 2008).

2.2. Sampling

Roads and tracks accessible by vehicle were surveyed at the end of the wet season (April) and of the dry season (November) in 2012. The distance driven was approximately 1250 km each season (Fig. 1) spatially organized to minimise the risk of double-counting animals. Drives were at less than 30 km/h with two experienced wildlife observers in the vehicle who scanned the terrain for ungulates constantly.

The vehicle stopped wherever there was a sighting of ungulates and the location noted using GPS (Garmin Csx60). The distance and bearing of the animals relative to the vehicle were noted respectively using a digital rangefinder (Leica 1200RF) and a precision compass. The species and total number of animals was noted for each sighting, as well as the number of females and yearlings in family groups detected in April sampling. Alongside the animal data, the habitat within 50 m radius of the central point of each sighting was described in terms of two topographical variables at small scale (position on hillside and surface roughness), the mean and maximum vegetation heights and the percentage plant cover, estimated visually for distinct vegetal formations (see Iranzo et al. 2013 for a similar approach). The altitude and gradient of each sighting was later added using the ASTER Global Digital Elevation

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