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Is human disturbance causing differential preference of agricultural landscapes by taruka and feral donkeys in high Andean deserts during the dry season?

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ABSTRACT

Areas with high shrub and grass cover are scarce and important for arid-land ungulates. Unfortunately, agricultural activities are often concentrated in such areas causing ungulates either to include croplands as foraging areas or being displaced to less desirable and more restrictive habitats. Considering this conflict, we assessed the spatial overlap of taruka (*Hippocamelus antisensis*) and feral donkeys (*Equus asinus*) at intermediate scales (0–2000 m) and compare their habitat preferences in the highland desert of northern Chile. We visited the area during the dry season; we estimated the vegetation cover and measured distance to croplands from animal sightings and control points. We found that there was an aggregated spatial pattern between donkey and taruka and both species used areas with shrub ($p = 0.770$) and bare ground cover ($p = 0.124$) as available. Nevertheless they differed on their location relative to crops (taruka used areas as available $p = 0.964$, feral donkeys avoided areas near crops $p < 0.001$). Our results suggest that there is a low potential for competition between species considering their habitat preferences. In spite of human persecution, this pattern appears to be driven by the taruka's dependence upon humid habitats near water and thus crops while feral donkeys can avoid such areas because of their tolerance of more arid environments than the native deer.

1. Introduction

In deserts, areas with high shrub and grass cover throughout the year are important and perceived as good habitats by wild ungulates, because they are a source of high quality food and shelter against natural predators (Pierce et al., 2004). Shrubs and grasses are scarce in deserts and form patchy patterns across the landscape, especially in proximity to water sources. Unfortunately, in human-modified arid environments agricultural activities are usually concentrated near water sources, where local farmers produce subsistence crops and compete with native plants and wildlife for space, soil and water. This overlap between human activities and wild organisms affects the viability of local ungulate populations in the long-term, because it enables wild ungulates to include crops as a new source of forage, which in turn creates human-wildlife conflicts, or forces them to move to poorer habitats (Verlinden, 1997).

In this study we focused on the northern Andean deer or taruka (*Hippocamelus antisensis)* and feral donkeys (*Equus asinus)* that inhabit human-modified areas in the Andean highland desert of northern Chile. This zone is dominated by native vegetation interspersed with crops that are planted on terraced hillsides near water

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sources (Goykovic, 2012). This technique of agriculture was inherited from the Aymara indigenous people, who started shaping this landscape ca. 3000 years ago (Rundel and Palma, 2000). In this environment the taruka, a mid-sized native deer, has coexisted with native people for thousands years (Rundel and Palma, 2000) and feral donkeys have increased their presence since their introduction in the 18th Century. Both species are pursued and poached by local farmers because they feed on alfalfa (*Medicago sativa*) crops throughout the year (taruka Sielfeld and Guzmán, 2011; feral donkey AV, pers. obs.). It is expected that an interspecific competition is occurring between both species for fresh vegetation and/or crops in this area. Our objectives here were the following: i) assess the spatial overlap of taruka and feral donkeys at intermediate scales, ii) describe the habitat preferences of taruka and feral donkeys, and their proximity to croplands, and ii) explore the potential for competition between both ungulates as the first step to understand their interspecific interaction in the highland desert of the Andean mountains.

2. Methods

The study area was located between 2500 and 4200 m above sea level in the Andean foothills of Arica y Parinacota and Tarapaca districts (18°11′49″S, 69°33′35″W). The total study surface was 904 km^2 where 45.52 km^2 were covered by crops. This highland desert zone is dominated by canyons and gullies interspersed with agricultural areas. Vegetation is characterized by high elevation shrub chaparral with a mean height <0.5 m (Luebert and Pliscoff, 2006) dominated by shrubs from genus *Baccharis* and *Parastrephia* and grasses from genus *Festuca* and *Stipa* (Villagran et al., 1981). Water is limited to gullies with streams, where human settlements, crops, and shrub cover concentrate (Goykovic, 2012). The average monthly temperature varies from 0 °C to 18 °C with an annual precipitation between 50 and 200 mm, concentrated between December and March (Novoa and Villaseca, 1989). The estimated population of taruka and feral donkeys in the study area are approximately 800 (RCE, 2007) and 1700 individuals (BG, pers. obs.) respectively. Agricultural crops are planted on terraced hillsides with high slopes near streams. The primary crops are corn (*Zea mays*), oregano (*Origanum vulgare*), potatoes (*Solanum tuberosum*), and alfalfa as pasture for llamas (*Lama glama*), alpacas (*Vicugna pacos*), cattle and sheep (Pérez, 2008).

The fieldwork was conducted during the dry season (4–27 August 2014), when the strongest influence of water availability on ungulate habitat preferences is expected (Pierce et al., 2004). Data were collected between 9 a.m. and 7 p.m. by four independent teams, who looked for taruka and feral donkeys while driving roads and walking line transects away from roads. Each transect was monitored once. We covered 484.7 km on transects travelled by car using a pick-up truck that went over the majority of roads within taruka distribution in Chile (Sielfeld and Guzmán, 2011). Only closed roads were not considered for safety reasons. We covered 40.7 km on 158 walking line transects that were separated from each other by 2.5 km. They randomly varied in eight directions (north, south, east, west, north-west, north-east, south-west and south-east) and five Euclidean lengths (150–350 m increasing by 50 m). Control points were set at the beginning and the end of line transects (Iranzo et al., 2013). Control points were set for estimating habitat availability in the study area and comparing it with availability in sighting points (Marcum and Loftsgaarden, 1980). When direct (encounters with animals) or indirect (faeces, footprints and skulls) animal signs were found, an observer recorded the geographical position using a GPS (Garmin GPSMAP® 60CSx) and visually estimated the proportion of surface with shrub cover and bare ground within a surrounding radius of 50 m following methodology in Iranzo et al. (2013). In order to describe 100% of the area other types of cover (e.g. water, natural grassland, wetland, buildings) were recorded, but those were not used in the analyses. Same vegetation estimation was performed in control points. Finally, the minimum distance from each sighting and control to crop fields was calculated using LANDSAT images and QGIS 2.4.0. Although livestock (llamas, alpacas, cattle and sheep) could compete with taruka and feral donkeys, they were not included in the analysis because their movement is limited to croplands and totally controlled by shepherds (Pérez, 2008).

We used taruka and feral donkey locations to perform a point pattern analysis in order to determine spatial overlap between species at intermediate scales (0–2000 m). We assessed spatial aggregation with the bivariate function L(r), which is a mathematic transformation of K- Ripley analysis using Passage software version 2 (Rosenberg and Anderson, 2011). If aggregation is detected, we can infer potential interspecific competition.

Differences in shrub cover, bare ground, and distance to crops between controls and sightings were assessed using generalized linear models (GLM) with quasi-Poisson distribution (log link function). Where vegetation cover and distance to crops were the predictive variables and total number of controls and sightings with specific vegetation cover and distance to crops were the response variables. Data from shrub and bare ground cover were grouped every 5% units (e.g. 0, 1–5%, 6–10% etc.), and from distance to crops every 25 m (e.g. 0, 1–25 m, 26–50 m etc.). Data from distance to crops were log transformed to improve their fit. To assess preference we used the index proposed by Neu et al. (1974) and clarified by Byers and Steinhorst (1984). Expected and observed usages were estimated from controls and sighting points respectively (Marcum and Loftsgaarden, 1980) and compared with chi-square test of homogeneity. When there was no significant difference between expected and observed usage ($p > 0.05$) we concluded the habitat usage was according to availability. When there was significant difference ($p < 0.05$), we visually assessed from the plot if there was preference (the slope of the observed usage is bigger than the slope of the expected usage) or avoidance (the slope of the observed usage is smaller than the slope of the expected usage) to that type of habitat (Byers and Steinhorst, 1984). All statistical analyses were performed in R (R Development Core Team, 2008).

3. Results

We identified 65 sites with taruka signs (12 groups, 42 faeces, 10 footprints, and 1 skull), 108 sites with feral donkey signs (7 groups, 82 faeces, 18 footprints, and 1 skull) and 310 controls points. Taruka

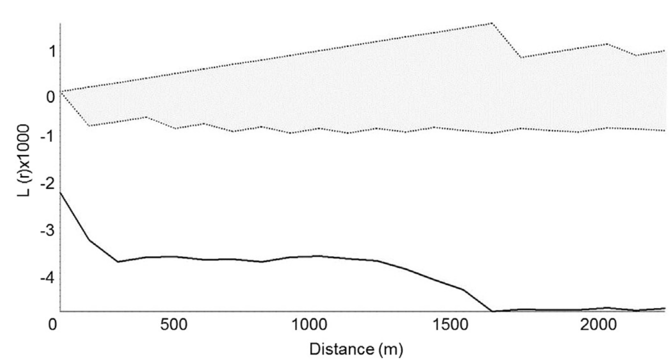

Fig. 1. Pattern of spatial aggregation between taruka and feral donkey. Grey area indicates random pattern with 95% confidence interval. Area above envelope indicates segregation and below indicates aggregation between species. Solid black line indicates the observed pattern.