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Original Investigation

Summer and winter diet of the guanaco and food availability for a High Andean migratory population (Mendoza, Argentina)

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ABSTRACT

Guanaco populations face different feeding constraints along their altitudinal migrations in Andean mountains. The guanaco's diet and food availability were analyzed using microhistological analysis and point-quadrat transects at four sampling sites from the summer range, and four sites from the winter range of a High Andean migratory population. Significant differences were detected with Kruskal–Wallis ANOVA, feeding selection by the χ^2 test, and dietary preferences by Bailey's confidence interval. Summer range was characterized by having higher plant diversity with more availability of grass-likes (Ciperaceae and Juncaceae) and forbs, compared to winter range. Sites with vegas (moist areas associated to streams and ponds, with dense hydrophytic vegetation) showed higher plant cover and diversity, also diet diversity was higher. Diet was dominated by grass-likes and grasses at sites with wetlands, only by grasses at the other sites, especially in winter. The highest diet-availability similarity occurred in the vega microhabitat, but species from slopes were also eaten at sites with wetlands. Grasses were preferred and shrubs were avoided in both seasonal ranges. The narrower guanaco's diet in winter, and the higher dietary diversity where plant cover and diversity are higher, both agree with the hypothesis of selective quality. A summer opportunistic feeding behavior shifts to a more selective behavior during winter. Winter browsing barely occurred, and grasses prevailed in the diet of both seasons. Altitudinal migration, forced by the deep snow, could favor guanacos to maintain a grazer strategy year round. Vegas and grasslands, in the summer and winter ranges, have a high feeding relevance for this guanaco population, and connectivity between both ranges is essential for their survival.

Introduction

Environments with steep topography, particularly those affected by heavy snowfall, tend to have strong spatial and seasonal differences in food availability for herbivores (Zweifel-Schielly et al., 2009). Seasonal movements of large herbivores are expected in these environments, in seeking to improve their access to food (Fryxell and Sinclair, 1988). Indeed, flexibility in foraging strategy and migrations are typical responses of ungulates to cope with heterogeneous availability of food and shelter (Solbrig, 1991). The winter snow cover was detected as one of the most important abiotic factors affecting the selection of resources by ungulates (Mysterud et al., 2007; Zweifel-Schielly et al., 2009).

Harsh climatic conditions, contrasting altitudinal levels and spatiotemporal heterogeneity in topography and vegetation characterize most Andean environments (Cabrera and Willink, 1980; Cavieres et al., 2000). Altitudinal movements have been reported for several guanaco populations in mountain environments, such as the west slope of the Andes in northern Peru and northern Chile (Franklin, 1975; Contreras et al., 2006), and both Andean slopes in southern Argentina and Chile (Prichard, 1902; Raedeke, 1979; Ortega, 1985). Climatic and food constraints were considered responsible for these migrations, additionally other factors such as the presence of livestock and the social structure of the guanaco (Bonacic et al., 1996; Contreras et al., 2006).

Mountain wetlands, locally named "vegas" (moist areas associated to streams and ponds, with dense hydrophytic vegetation) scattered across the dry Andean environments constitute confined but important sources of succulent food and water for wildlife (Roig and Roig, 2004; Squeo et al., 2006). A heavy dependence on meadow vegetation was observed in family and male groups of guanacos within the summer range of a migratory population in southern Chile (Jurgensen, 1985; Ortega, 1985).

The guanaco population of "Laguna del Diamante" Reserve exhibits an important altitudinal migration, forced by the deep snow that covers a considerable area of this High Andean environment for about eight months in the year (Mónaco, pers. comm.). The objective of this study was to analyze diet composition and food availability in summer and winter ranges for a High Andean

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migratory guanaco population. Specific objectives are to detect: (a) whether the guanaco's diet is broader and less selective where food availability is poorer (i.e. with less plant cover and food diversity), as is expected from the optimal foraging theory, (b) whether the diet in habitats with vegas excludes plant species from slopes, due to the expected feeding attraction of vegas, and (c) whether the diet shifts from grazing to browsing during the winter decline of vegetation, as was detected for the guanaco in other environments.

Material and methods

Study area and habitat characteristics

The study area, belonging to the protected area "Laguna del Diamante" (34°10′S 69°41′W, 1700 km^2, Mendoza, Argentina), is representative of the High Andean biogeographic province (Cabrera and Willink, 1980). The Maipo volcanic complex (5323 m a.s.l.), the Diamante lagoon (18 km^2) and the extended mountain wetland Vegas del Yaucha (14 km^2) stand out in this study area. The area is characterized by an important altitudinal gradient from West to East (5300 to 2300 m a.s.l.).

The summer range of the guanaco population is located in the west part of the study area, corresponding to the Main Andean Cordillera (Mesozoic period). With altitudes higher than 3300 m a.s.l., this environment is characterized by glacial deposits such as till, moraines, thermokarst, rock glaciers, glacial valleys, avalanches and landslides (Abraham, 2000; Sruoga et al., 2005). A tundra climate dominates this high mountain environment, with an eternal-ice polar climate at heights of the Maipo volcano (Norte, 2000). Annual precipitation averages 600 mm, and occurs mostly as snowfall from April to September (Mónaco et al., 2005). The numerous vegas are mountain wetlands dominated by grass-likes (Ciperaceae and Juncaceae), and contrast with the surrounding arid vegetation characterized by nanophanerophytes and grasses (Roig et al., 2000). Four sampling sites were selected, representative of the main habitats used by guanacos during summer, with vegas being present in two of them and absent from the other two habitats (Table 1).

The winter range of the guanaco population occupies the east part of the study area, where altitudes are lower than 3300 m a.s.l. This mountain environment corresponds to the Frontal Cordillera (Paleozoic period), and presents an aggradational piedmont plain to the East (Abraham, 2000; Sruoga et al., 2005). A desert climate (Norte, 2000), with 400 mm of annual precipitation (Mónaco et al., 2005), determines a vegetation dominated by grasses, supplemented with chamaephytes or phanerophytes (Roig et al., 2000). Four sampling sites were selected, representative of the main habitats used by guanacos during winter, two of them located on slopes and the other two in piedmonts (Table 1).

Field and laboratory design

Samplings were made during 2007, corresponding to mid summer (February) and late winter (September). Plant cover and relative frequencies of plant species were estimated by the point-quadrat method (Daget and Poissonet, 1971), applied on 10–20 transects per sampling site, depending on the habitat heterogeneity associated to the presence of wetlands. Vegetation sampling was stratified according to the contrasting microhabitats recognized at both sites with wetlands. All 30-m transects were distributed within each sampling site in a stratified random design, separated from one another by more than 100 m. Fecal samples were collected on each date from 10 groups of feces selected from each sampling site. Each fecal sample, composed of 10 fresh pellets, was collected from a different active communal dung pile. After being oven-dried at 60 °C, each fecal sample was ground, cleared with diluted lye (aqueous sodium hypochlorite, 25%, w/v), and passed through a 70 μm sieve. Fecal samples were analyzed with the microhistological method of Baumgartner and Martin (1939), modified by Duci (1949) and Holechek (1982), using plant reference material from "Laguna del Diamante" Reserve, collected and identified during the present study and stored in the Ruiz Leal Herbarium (IADIZA, Argentina). Plant cuticle was identified to genus level, and to species level when possible.

Statistical analyses

Plant cover was determined for each point-quadrat transect by dividing the number of points at which any plant species was contacted (except dead individuals) by the 100 transect points. Relative frequency of a given plant species in the environment was determined by dividing the absolute frequency of this species by the total sum of absolute frequencies for all species identified on each point-quadrat transect. Food availability analyses only considered the plant species consumed by guanacos on at least one occasion in each season. The relative frequency of a species in the diet was determined for each sample by dividing the number of microscopic fields in which a given species occurred by the sum total of frequencies for all species identified (Holechek and Gross, 1982).

Plant species were grouped into four categories according to life form: grass-likes, grasses, shrubs and forbs. Diversity in food availability and diet was estimated using the Shannon–Wiener function (H', Colwell and Futuyma, 1971). Plant cover, diversity, proportion of plant species and categories were analyzed with the Kruskal–Wallis ANOVA and Tukey test (H and q, Zar, 1984) for multiple comparisons among the four sampling sites for each season (df = 3) and between seasons (df = 1), in order to detect significant spatial and temporal differences in availability and diet. The level of significance obtained was mostly $p \leq 0.001$; otherwise, it is mentioned in the text. The percentage of overlap (O, Hurlbert, 1978) was applied to estimate similarities between availability and diet. Feeding selection was detected through significant differences between observed and expected dietary proportions by using the χ^2 test (Zar, 1984). Bailey's confidence interval (Cherry, 1996) was used to identify selective use of the main species (species with frequencies equal to or higher than 5% in their availability and/or in the diet). Plant use was qualified as preference, no selection or avoidance depending on whether availability was respectively located below, within or above the confidence interval of dietary frequency.

Results

Food availability

Of all plant species recorded on the sampling sites (59 species in the summer range, and 47 species in the winter range), 56% of them constituted food availability for guanacos in each season. Summer and winter ranges did not differ significantly in plant cover or diversity, whereas a lower proportion of grasses (H = 40.60) and higher proportions of grass-likes and forbs (H = 25.57 and H = 11.55, respectively) differentiated the summer from the winter sampling sites (Fig. 1). Additionally, food availability in the summer range differed slightly from that of the winter range by having a higher proportion of the major plant species (H = 4.20, p = 0.040) and fewer dominant species (those with proportions higher than 10%; H = 6.65, p = 0.010).

Food availability in the summer range

A high proportion of grass-likes, supplemented with shrubs, characterized the sampling sites with vegas, whereas grasses and