



Habitat use and selection by the vicuña (*Vicugna vicugna*, Camelidae) during summer and winter in the High Andean Puna of Argentina

M. Eugenia Mosca Torres*, Silvia Puig

Vertebrate Ecology and Management Group, IADIZA, CCT Mendoza, CONICET, CC 507, 5500 Mendoza, Argentina

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ABSTRACT

Habitat use and selection by vicuñas and particularly by individuals of different social categories were evaluated during the summer and winter of two years (2006 and 2007) that differed in their precipitation pattern. Both, use and selection, were analyzed within the framework of the optimal foraging theory (OFT) that predicts a high proportion of individuals using habitats where the most nutritional food items are present, and if other things are equal, habitats should be chosen if they yield the highest average rate of energy intake, which fits with this theory. Indeed, a prediction of the habitat selection theory (HST) was evaluated during winter (dry season). Over the study period high proportions of vicuñas occupied habitats with availability of high quality food, which supports the OFT. However, habitat selection differed between seasons and years due to the decrease in plant resource availability in the winter of both years and in the summer of 2007 (with drought conditions). In the dry season of the good year (2006), vicuñas (familial individuals, particularly) were more homogeneously distributed among habitats than in summer, which is consistent with the HST. High proportions of individuals at the wetland (called *vega*) were more evident during the bad year (2007) than in the good one. Therefore, habitat use (and selection) by vicuñas in this sector of the Puna region is influenced by the availability of high quality food resources and by the presence of water, and the relevance of the latter increased with drought conditions. An assessment of the interactions between individuals of different social categories will contribute to better understanding the distribution of animals among different habitats.

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1. Introduction

Habitat use and selection studies are essential for understanding the animals' biological requirements and the strategies they use to fulfill their needs (Manly et al., 1993). Habitat selection occurs when an animal chooses which habitat resources (physical and biological) to use for growing, surviving, and reproducing (Green and Stamps, 1991; Johnson, 1980; Manly et al., 1993), whereas habitat

use is the way an individual uses different resources present in a particular habitat (Hall et al., 1997). In animals who live in groups, social interactions may influence habitat use affecting the efficiency with which the individuals satisfy their appetite drive, through competitive or agonistic interactions (Duncan and Gordon, 1999). In that sense, Mosley (1999) suggested that social competition may force subordinate individuals away from preferred areas.

Availability of water sources and seasonal differences in food availability are other factors that can strongly influence habitat use and selection by ungulates (Duncan and Gordon, 1999; Fryxell and Sinclair, 1988; Redfern et al., 2003; Sinclair and Fryxell, 1985; Traill, 2004), particularly in arid or semi-arid environments where quality and

* Corresponding author at: Av. A. Ruiz Leal s/n CC 507, CP 5500 Mendoza, Argentina. Tel.: +54 261 5244130; fax: +54 261 5244001.

E-mail addresses: metorres@mendoza-conicet.gob.ar (M.E. Mosca Torres), spuig@mendoza-conicet.gob.ar (S. Puig).

availability of food resources decrease dramatically during the dry season (Owen-Smith and Novellie, 1982). Interannual variations in precipitation patterns are common in these environments. In the High Andes these variations are generally a consequence of El Niño-Southern Oscillation (Trenberth and Caron, 2000), causing droughts during the wet season and exacerbating the scarcity of food resources in the environment (Holmgren et al., 2001).

The optimal foraging theory (Pyke et al., 1977; Stephens and Krebs, 1986) proposes a model to explain habitat use by animals. One of the predictions of this theory is that individuals should concentrate in habitat types where the availability of the most nutritional food items are high (Quintana et al., 2002). In the case of habitat selection, models predict that habitats should be chosen if they yield the highest average rate of energy intake, which fits with the optimal foraging theory (Krebs et al., 1981; Schoener, 1971). Therefore, it is predicted that the proportions of individuals observed in high quality habitats will be higher than the proportions expected from a random distribution, due to animals preference for those habitats. When resource availability decreases in the best habitats (particularly in winter), the habitat selection theory predicts that the distribution of animals among habitats should become more homogeneous (Sutherland, 1996).

The vicuña (*Vicugna vicugna* Molina 1872) is the smallest South American camelid and has been hunted to near extinction until 1960 (Torres, 1992). The establishment of conservation programs since 1969 have been effective for several populations of vicuñas, and this species has been changed to the current “least concern” IUCN status (IUCN, 2001). The distribution range of this species in Argentina comprises high altitude environments of the High Andean and Puna biogeographic provinces (Torres, 1992). Vicuñas are considered an important economical resource because they have the finest animal fiber in the world (FAO, 1987). Therefore, the demand for their products is considerable, and the ability to generate employment is high (Lichtenstein, 2006).

This camelid has a stable social structure, composed of family groups (territorial animals), bachelor groups (non-territorial animals), and solitary individuals (with or without an established territory; Cassini et al., 2009; Franklin, 1983; Koford, 1957). The territorial behavior of familial males would determine vicuña distribution in the environment because they defend sites with high quality resources to provide sufficient food to females, particularly during pregnancy and lactation periods (Mosca Torres and Puig, 2010; Vilá and Cassini, 1993). Bachelor males display greater movement due to lack of territory (Arzamendia and Vilá, 2006; Mosca Torres et al., 2006) and generally occupy environments with variable or marginal quality vegetation away from territorial areas with higher quality resources (Cajal, 1989; Franklin, 1983; Koford, 1957). The vicuña is considered an obligate-drinker due to its strong dependence on water (Franklin, 1983; Vilá and Roig, 1992).

Habitat use by vicuñas in the Puna of Peru (Franklin, 1983; Koford, 1957) and some areas of Argentina (Cajal, 1989; Renaudeau d’Arc et al., 2000; Vilá and Cassini, 1993; Vilá and Roig, 1992) is determined mainly by the terrain, availability of resources (water, food and shelter), climatic

factors, time of day and social structure. However, there is scant information available about habitat use and selection by this species within the framework of the optimal foraging theory. Moreover, no information is available on the ecology of this species in Salta, Argentina. Therefore, results of this research provide more knowledge of the selective behavior of this small ruminant.

This study analyzes the different habitat types occupied by the vicuña in Unquillal (High Andes, Salta, Argentina), the habitat use and selection by this species particularly by different social categories, during the summer and winter (corresponding to maximal and minimal resource availability, respectively) of 2006 and 2007. The specific objectives are to detect: (a) whether there are changes in the habitat occupancy by social categories of vicuñas among years, seasons and times of the day, and (b) whether vicuñas actively select different habitats within the study site, particularly when food resource availability is maximal.

We predict that the proportion of vicuñas using habitats with high availability and high quality of food resources will be greater than in habitats with lower food quality and availability. Additionally, since this species has a strong dependence on water, especially during the dry season (Renaudeau d’Arc et al., 2000), we expect to find a higher proportion of animals in wetlands (called *vegas*) during the winter than in summer, and during a dry year than in a good year. Finally, we predict that vicuñas will show differences in the daily pattern of habitat use between seasons and years, due to the changes in food quality and availability.

In relation to habitat selection, we expect that the proportion of vicuñas will be higher in habitats with high food availability than the proportion expected from a random distribution, particularly during the summer of a good year when food availability is maximal. On the other hand, distribution of individuals among different habitats should be more homogeneous in winter when food availability decreases. At intraspecific level we predict that familial individuals will prefer habitats with high quality food resources because of the high energy demands of female vicuñas during lactation and gestation periods.

2. Materials and methods

2.1. Study Area

The study area, *Unquillal* (24°27’S and 67°12’W, 8.6 km²) is located within the Los Andes Reserve in the NW region of Salta province (Argentina). The Reserve is a 14,400 km² protected area representative of the Puna biogeographic province (Cabrera and Willink, 1980), whose objective is to conserve natural resources (especially the vicuña). The climate is cool and dry, with broad daily and seasonal temperature range (between 2 °C and 18 °C in summer, and 12 °C and 16 °C in winter), scarce rainfall (130 mm/yr) occurring only in summer (e.g. wet season; December–March) and intense frosts.

Seasonal growth and quality of vegetation are determined by the precipitation pattern. During the wet season (summer) plants grow quickly and have high nutritional quality, but this period is only 3–4 months in duration

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