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Short Communication

# *Mazama gouazoubira* (Cervidae) diet during the dry season in the arid Chaco of Córdoba (Argentina)

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ABSTRACT

Grey brocket deer diet selection was studied during a period of water scarcity in the arid Chaco of Córdoba province, Argentina. Sampling took place during the dry season in and around Chancaní Provincial Reserve (Pocho department). Forty-eight fresh fecal samples were collected from 85 sampling plots located at random. Plant cover and abundance were used to estimate food availability. Diet composition was determined using microscopic analysis of brocket feces and resource selection was calculated using Ivlev's Selectivity Index. Thirty-three plant species were identified in the diet. Fruits were found in high proportion (12.4%). Woody plants made up 67.7% of the diet; the most consumed species were *Castela coccinea* (23.1%), *Maytenus spinosa* (10.2%), *Condalia microphylla* (9.5%), *Schinus fasciculatus* (8.5%) and *Ximena americana* (7.4%). *Mazama gouazoubira* selects woody and succulent plants, while herbs are consumed according to availability and grasses in a proportion that is below what is available.



## 1. Introduction

The gray brocket deer (*Mazama gouazoubira*) has the widest distribution of all the brockets, extending from Central America to northern and central Argentina (Emmons and Feer, 1997). It is a typical inhabitant of forest and edge areas, showing preference for forests with a high level of vegetation cover (Parera, 2002). *M. gouazoubira* shows a varied diet, predominantly herbivorous-frugivorous, with variations in the composition and relative importance of different items according to the environment where it is found (Bodmer, 1991; Richard et al., 1995; Varela, 2003). Studies on brocket deer diet in the Chaco region of Argentina (Cartes Yegros, 1999; Kufner et al., 2008) showed a feeding preference for woody plants (mostly leaves and branches) and fruits. According to Oesterheld et al. (1999), the amount and distribution of precipitation can influence primary production and food availability, particularly in arid and semi arid areas. This dependence on precipitation can lead to critical periods which can influence the behavior, movement and feeding habits of the local fauna (Manly et al., 2002). In the arid Chaco, scarce annual rainfall and high temperatures create a hydric-deficit period that can last several months each year, affecting the survival of grey brocket deer populations due to a decrease in leafy plants and vegetation cover (Cartes Yegros, 1999). The present study describes the grey brocket deer's diet as well as its selectivity for certain food items during a critical period of scarce resources in and around a protected area of the arid Chaco, where the brocket population is abundant (Periago and Leynaud, 2009).

## 2. Methods

The study was conducted in Chancaní Provincial Natural Park and Forest Natural Reserve (Chancaní Reserve) (30°22′ S, 65° 26′ W) and surrounding areas. The reserve is located in the southernmost portion of the Chaco, in a section designated Arid Chaco, and has an average annual rainfall of 425 mm, concentrated in the spring and summer months (November–March). Mean annual temperature is 18 °C, with a mean value of 25 °C in the warmest month (January) and 10 °C in the coldest month (July). The dominant vegetation is dry semideciduous woodland, dominated by *Aspidosperma quebracho-blanco* and *Prosopis flexuosa*, and a dense shrub stratum dominated by *Larrea divaricata*, *Mymozyganthus carinatus* and *Acacia furcatispina* (Carranza et al., 1992; Cabido and Pacha, 2002; Bonino and Araujo, 2005).

Sampling was carried out from August to October 2007. Fecal samples were collected and vegetation variables were measured in 85 sampling plots, selected at random from a 150 $m^2$ cell grid placed on top of an aerial image of the region. The plots were 600 $m^2$ each, at least 1 km apart and distributed throughout 4960 ha of the reserve and adjacent areas. Fresh grey brocket deer

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pellets were identified by size and deposition mode (dung piles). To estimate food availability, plant cover was measured at extreme points of each plot as follows: herb and grass cover (%) was estimated using a 1 $m^2$ quadrant, and shrub and tree cover (woody plants) (%) was estimated in a 10 m × 10 m plot using a Spherical densiometer (Hays et al., 1981). Trees taller than 1.5 m were not considered, as they are considered inaccessible to this species. Plant species abundance was determined by counting individuals using the quadrant used for herbs and grasses, and plots for trees and shrubs. These variables were selected following the recommendations of Campos (1997) and were used to quantify food availability as a measure of approximate biomass available (De Jong et al., 1995).

For the identification and comparison of dietary components, vegetation samples were collected from the study area to create the reference material. The specimens were identified (to species level when possible) and reference slides were prepared (Rosati, 1991). Diet composition was studied using the microhistological technique, which allows the identification of plant fragments in the feces collected (Williams, 1969; Latour and Pelliza Sbriller, 1981). This technique has been widely used because of its precision in determining diet components, its practicality in collecting the necessary samples, and, most importantly, because it does not disturb the animal in any way (Ojasti, 1973; Holechek, 1982; Holechek and Gross, 1982). Three slides were prepared for each of the 48 fresh fecal samples collected, as indicated by Hansen et al. (1978). The reference material and the fecal samples were processed following the modified method described by Dacar and Giannoni (2001). Three slide readings were made with a 40x lens, observing 50 fields systematically per slide. When possible, vegetation fragments were identified by epidermal characteristics and seed fragments were identified by endosperm and embryo characteristics using the reference material. Only fragments that had at least two diagnostic characters were considered as evidence of species presence.

Plant species were grouped into four cover types using a modified classification of Cabido and Pacha (2002): woody plants (trees and shrubs), grasses, herbs and succulents, as well as a fifth group which included fruits. The term “dietary item” refers to different taxonomic levels depending on which level was determined microhistologically. Grey brocket deer diet composition was determined using relative frequency of occurrence (Holechek and Gross, 1982). The relative frequency of each plant species in the environment, or offer (oi), and its relative frequency in the diet (di) determined trophic preferences at three levels: (1) general diet composition, (2) preference for different items, and (3) selectivity of the preferred items.

The food preference index (PI) (Hobbs and Bowden, 1982) is the ratio between the percent relative frequency of each plant group in the diet and the percent relative frequency of each plant group in the study area. The standard error (SE) and the confidence intervals (Hobbs and Bowden, 1982) of PI were calculated to determine selectivity of the available resource. We assume that an animal: (a) selects a resource if the minimum confidence interval (PI−2 SE) is higher than 1, (b) does not select a resource if the maximum confidence interval (PI+2 SE) is lower than 1, or (c) utilizes the resource in the same proportion as it is available when the confidence interval includes 1. This means that a diet item can be chosen (its proportion in the diet is higher than its proportion in the environment), avoided (its availability is higher than that consumed) or neutral (the proportions are similar in the diet and the environment) (Crawley, 1983).

Selectivity was calculated for the preferred species in the diet using Ivlev’s Selectivity Index, Ei, where Ei: di − oi/di + oi (Krebs, 1999). The value of Ei varies between −1 and +1. Values between 0 and +1 indicate preference and values between 0 and −1 indicate avoidance. According to Krebs (1999), a species is preferred when it is found in larger proportions in the diet than that available in the environment (selectivity), it is rejected when the opposite occurs, and consumed at random (opportunism) when Ei = 0, meaning that the proportion in the diet is similar to that available in the environment. We consider selectively consumed species at an Ei between 0.7 and +1 (following criteria from Franzel and Farji-Brener, 2000).

## 3. Results

We identified a total of 39 species available to the grey brocket deer in the study area (foliage was less than 60 cm above ground), 14 of which were not identified in the fecal samples analyzed. Of the 39 species identified, 27 were woody plants, eight were herbs, three were grasses and one was a pteridophyta. Succulents were either cacti or bromeliads; we were unable to differente genus or species. The availability of food items in the area was dominated by woody plants with 62.1% cover, followed by grasses (26.3%), herbs (7.5%), succulents (2.8%) and the pteridophyte, *Selaginella sellowii* (1.3%). A total of 33 plant species were identified as components of grey brocket deer diet during the study period (Table 1). The most abundant vegetation type consumed according to the relative frequency of all the samples analyzed were woody plants (67.7%) and succulents (11.2%). Herbs were consumed at low proportions (6.7%) and grass consumption was very low, reaching only 2.0% (Table 1). Of the 19 identified woody plants, 14 were identified to species level and five to genus level. The most consumed species were *Castela coccinea* (23.1%), *Maytenus spinosa* (10.2%), *Condalia microphylla* (9.5%), *Schinus fasciculatus* (8.5%) and *Ximenia americana* (7.4%), which represent more than 50% of the plants ingested by the deer (Table 1). The succulents corresponded to species in the Cactaceae and Bromeliaceae families. Eight species of herbs were also found, four of which were not identified. Six species of fruits

**Table 1**
Plant composition of grey brocket deer diet in Chancaní Reserve (Córdoba) during the dry season. The results are expressed in average percentages of the occurrence of the item in the diet.

| Relative frequency of species found in diet (%) | | | |
|---|---|---|---|
| Woody plants | | Grasses | |
| *Acacia furcatispina* | 0.1 | UG[a] | 2.0 |
| *Aloysia gratísima* | 2.8 | ***Total*** | **2.0** |
| *Buddleja sp.* | 0.3 | **Herbs** | |
| *Bulnesia sp.* | 0.1 | *Gomphrena sp.* | 0.4 |
| *Capparis atamisquea* | 1.4 | *Justicia squarrosa* | 0.1 |
| *Castela coccinea* | 23.1 | *Malvastrum coromandelianum* | 5.0 |
| *Celtis tala* | 0.9 | *Poligonum sp.* | 0.6 |
| *Condalia microphylla* | 9.5 | UH[a] 1 | 0.1 |
| *Geoffroea decorticans* | 0.8 | UH[a] 2 | 0.2 |
| *Larrea divaricata* | 1.0 | UH[a] 3 | 0.1 |
| *Lycium sp.* | 0.1 | UH[a] 4 | 0.2 |
| *Maytenus spinosa* | 10.2 | ***Total*** | **6.7** |
| *Mimozyganthus carinatus* | 0.1 | **Fruits** | |
| *Prosopis sp.* | 0.5 | *Bulnesia bonaeriensis* | 0.9 |
| *Prosopis torquata* | 0.1 | *Castela coccinea* | 6.4 |
| *Schinus fasciculatus* | 8.5 | *Condalia microphylla* | 0.1 |
| *Tricomaria usillo* | 0.2 | *Opuntia sp.* | 3.2 |
| *Ximenia americana* | 7.4 | *Schinus sp.* | 0.7 |
| *Zizyphus mistol* | 0.6 | *Ximenia americana* | 0.5 |
| ***Total*** | **67.7** | UF[a] | 0.6 |
| **Succulents** | | ***Total*** | **12.4** |
| Bromeliaceae | 0.6 | | |
| Cactaceae | 10.6 | | |
| ***Total*** | **11.2** | | |

[a] Unidentified herb species are indicated as UH; unidentified fruits are indicated as UF; unidentified grass species are indicated as UG.

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were identified, which comprised 12.4% of the diet. Almost 70% of the fruits identified belonged to woody plants: *C. coccinea* (6.4%) *Bulnesia* sp. (0.9%), *Schinus* sp. (0.7%), *X. americana* (0.5%) and *C. microphylla* (0.1%). Fruit consumption belonging to succulents was represented by cacti (3.2%). Unidentified fruits represented 0.6% of the diet.

According to the PI values and the corresponding confidence intervals (±2SE), during the study period, the grey brocket deer preferred leaves of woody plants ($PI = 1.23 \pm 0.02$) and succulents ($PI = 5.12 \pm 0.22$) above herbs ($PI = 0.94 \pm 0.24$) and grasses ($PI = 0.07 \pm 0.18$). Herbs were eaten in proportion to their availability and grasses were eaten in smaller proportion to their availability or were not selected. We evaluated Ivlev's index for woody plants and succulents, as they made up more than 70% of the brocket's diet (Table 2). The most frequently selected species consumed with Ei values higher than 0.7 were the leaves of *Aloysia gratissima*, *C. coccinea*, *C. microphylla*, *M. spinosa*, *S. fasciculatus*, *Tricomaria usillo* and *X. americana*, as well as *Cactaceae* (Table 2).

## 4. Discussion

Grey brocket deer diet composition shows, throughout its extensive distribution, a wide diversity of plant species when compared to the smaller amount offered in different types of environments. Even though studies in secondary forest areas of the Yungas (Richard et al., 1995) recorded more than 70 species present in the brocket's diet, the diversity found in the present study (33 species) is similar to that found in other studies using the same method and in areas closer to the southern distribution of the species. Cartes Yegros (1999) found 38 species in the plains of La Rioja, while Kufner et al. (2008) found 25 species near Dean Funes (Córdoba). In both cases, the data corresponds to the dry season. The higher proportion of species found in Chancaní Reserve than that reported by Kufner et al. (2008) can be due to a higher availability of plant species found in a protected area (Chancaní Reserve) than in the semi arid degraded areas near Dean Funes.

Within the high diversity of plant species consumed by the brockets, the dominant items corresponded to woody plants, which is consistent with previous studies (Richard et al., 1995; Cartes Yegros, 1999; Kufner et al., 2008). As Kufner et al. (2008) state, the brocket's diverse diet constitutes a positive attribute for the survival of its populations. Our results support the above statement considering that of the 39 species identified and considered available to the brockets in the study area, 20 were found in the diet. Even though the brocket's diet as described in this study resulted in a diverse number of species, a few items stand out as being consumed selectively (*C. coccinea*, *M. spinosa*, *C. microphylla*, *S. fasciculatus* and *X. americana*) and represent more than 60% of the diet. The abundance of resources does not seem to determine consumption since most of the brocket's diet is composed of a few preferred species, regardless of their abundance in the habitat. We can therefore infer that the grey brocket deer may indeed actively seek these species for consumption. Brockets probably select a reduced group of plants that contain higher quality nutrients, reducing the cost of food seeking (Krebs, 1999). This finding agrees, in general terms, with studies that show deer as intermediate selectors and great opportunists that evolved to occupy young and highly productive ecosystems (Geist, 1998).

It has been proposed that a higher selectivity by the animals occurs mainly during periods of scarce resources when palatable and higher nutritional quality plant species are proportionately less available (Bell, 1971; Hobbs et al., 1983; Bergueron and Jodoin, 1987; Putman, 1988). The higher consumption of leaves of certain plant species may make the grey brocket deer an important selection agent in regards to adaptability, anti-herbivory defence levels and distribution of vegetation in the study area, at least for the period studied. *Mazama gouazoubira*'s ability to feed in a selective manner (on woody and succulent plants) as well as in an opportunistic manner (from herbs), and to adjust to variations in resource availability, can explain its extensive geographic distribution.

In this study, fruits were the second most consumed item, which is consistent with the fruting pattern of the woody plants consumed (Varela, 2003), with a peak in the spring season. No fragments or full seeds were found, suggesting that they were either regurgitated during the feeding process, or that the gastrointestinal fluids digest the entire seeds (Bodmer, 1991; Varela, 2003). However, this can also mean that the brockets are consuming only the fleshy parts of the fruit. The fruits found consumed in our study coincide with those found by Stalling (1984), Cartes Yegros (1999) and Varela (2003), who also found a significant consumption of fruits belonging to *C. coccinea*, *X. americana* and cacti. The high proportion of succulents ingested in the study period, characterized by an elevated hydric deficit, is similar to that found in other studies with brocket deer in extreme dry areas like the boreal Chaco of Paraguay (Stalling, 1984) and the plains of La Rioja (Cartes Yegros, 1999), during the same season. The selection of succulent plants and cacti detected in this study is possibly related to the deer's water requirements (Stalling, 1984; Sombra and Mangione, 2005), which seems consistent, as the study was conducted during the dry season when water was limited. Our results suggest that leaves of woody plants, cacti and the fruits of both are important sources of food and water for the grey brocket deer in Chancaní Reserve, which allows them to survive in arid areas during a period of scarce resources.

These results contribute critical information regarding the ecology of native fauna and are important when planning and designing management strategies in protected and surrounding areas. It is important to consider the dietary habits, including degree of selectivity of certain plants, when working with species that are found in altered environments, secondary habitats and forest edges, and as pointed out by Kufner et al. (2008), when there is the possibility of competition with introduced species.

**Table 2**
Grey brocket deer trophic preference for woody plants by species, according to Ivlev's index (Ei).

| Species | Offer (relative frequency) | Diet (relative frequency) | Selectivity Index |
|---|---|---|---|
| **Woody plants** | | | |
| *Acacia furcatispina* | 8.1 | 0.1 | −1.0 |
| *Aloysia gratissima* | 0.2 | 2.8 | **0.9** |
| *Capparis atamisquea* | 1.5 | 1.4 | 0.0 |
| *Castela coccinea* | 0.5 | 23.1 | **1.0** |
| *Celtis tala* | 0.5 | 0.9 | 0.3 |
| *Condalia microphylla* | 1.6 | 9.5 | **0.7** |
| *Geoffroea decorticans* | 1.9 | 0.8 | −0.4 |
| *Larrea divaricata* | 25.3 | 0.6 | −1.0 |
| *Lycium sp.* | 0.5 | 0.0 | −0.9 |
| *Maytenus spinosa* | 0.9 | 10.2 | **0.8** |
| *Mimozyganthus carinatus* | 7.5 | 0.1 | −1.0 |
| *Prosopis torquata* | 0.3 | 0.1 | −0.6 |
| *Schinus fasciculatus* | 0.2 | 8.5 | **1.0** |
| *Tricomaria usillo* | 0.0 | 0.2 | **0.8** |
| *Ximenia americana* | 0.4 | 7.4 | **0.9** |
| *Zyziphus mistol* | 0.6 | 0.6 | 0.0 |
| **Succulents** | | | |
| Bromeliaceae | 2.0 | 0.5 | −0.6 |
| Cactaceae | 0.8 | 10.6 | **0.9** |

Values greater than 0.7 indicate a preference for a certain species and are shown in bold.

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