

# Feeding ecology of *Ozotoceros bezoarticus*: conservation implications in Uruguay

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**ABSTRACT.** The pampas deer (*Ozotoceros bezoarticus* Linnaeus, 1758) was in the recent past one of the most characteristic species in the Uruguayan grasslands. However, today the species is very rare, with small relict populations inhabiting in few ranches. To improve our understanding of pampas deer habitat use in modified ecosystems and propose management guidelines we analyzed the pampas deer feeding ecology at Los Ajos ranch. We performed an annual vegetation survey with the purpose to identify the main components of pampas's deer diet and the spatial overlap with livestock. Vegetation offer was characterized by predominance of monocotyledon plants; in three of the four sample periods. The preference values for the crops were positive for ryegrass in winter (0.24) and spring (0.54), the moments of greatest productivity of this pasture; while the rice crops values were negative all year round. The spatial overlap indexes with sheep show a complete exclusion, whereas with cattle the indexes gave values of 0.95 in spring to 0.14 in summer. The niche amplitude was significantly correlated with the spatial overlap levels with cattle. Pampas deer foraging behaviour is opportunistic, typical of mixed feeders. Conservation efforts should focus on implementation of management guidelines of agriculture and cattle breeding activities.

**KEYWORDS.** Diet, habitat use, mixed feeders, niche overlap, pampas deer.

**RESUMO. Ecología trófica de *Ozotoceros bezoarticus*: implicaciones para su conservación en Uruguay.** El venado de campo (*Ozotoceros bezoarticus* Linnaeus, 1758) fue en el pasado reciente una especie focal de las pasturas uruguayas. Sin embargo, hoy día es una especie rara, con pequeñas poblaciones aisladas que ocupan establecimientos agropecuarios. En este trabajo se analizan aspectos de la ecología trófica en una población de venado de campo. El objetivo es: comprender la interacción entre esta especie y un ecosistema modificado por la actividad agrícola-ganadera. Se busca así proponer medidas de manejo de la población y del ambiente que ocupa. En este trabajo se identifican los principales componentes de la dieta y el grado de solapamiento espacial con el ganado doméstico, para ello se realizó un muestreo anual de la vegetación, se colectaron fecas de venado de campo y se analizó la distribución espacial de los distintos herbívoros que ocupan el establecimiento agropecuario. La oferta de vegetación se caracterizó, en tres de cuatro períodos de muestreo, por una predominancia de plantas monocotiledóneas. Los valores de preferencia para los cultivos fueron positivos para el ryegrass en invierno (0.24) y primavera (0.54), los momentos de mayor productividad de esta pastura; mientras que el cultivo de arroz mostró valores negativos de preferencia a lo largo de todo el año de estudio. Los índices de solapamiento espacial mostraron una completa exclusión con el ganado ovino, mientras que con el ganado bovino se obtuvieron índices de 0.95 en primavera a 0.14 en el verano. La amplitud de nicho tuvo una correlación significativa con el nivel de solapamiento espacial con el ganado vacuno. El comportamiento de forrajeo del venado de campo es oportunista, típico de los rumiantes de tipo intermedio (*mixed feeders*). Los esfuerzos de conservación deben focalizarse en la implementación de lineamientos de manejo de las actividades agrícolas-ganaderas.

**PALABRAS CLAVE.** Dieta, uso del hábitat, rumiantes intermedios, solapamiento de nicho, venado de campo.

Pampas deer *Ozotoceros bezoarticus* Linnaeus, 1758, are native ungulates of the open grassland habitats of South America (from 5° to 41°S; CABRERA & YEPES, 1940; JACKSON, 1987). Over the last two centuries, their natural habitats (Pampas, Cerrado and grasslands of Argentina, Uruguay, Paraguay, Bolivia and southern Brazil) have been drastically modified by agricultural activities (GONZÁLEZ, 1993; FONSECA *et al.*, 2000). Pampas deer have been deeply affected by habitat modification and fragmentation and which are considered one of the main causes of the reduction of the number and size of wild populations throughout its range.

The process of population decline of the species is clearly visible in Uruguay, which is home to two endemic subspecies: *O. b. arerunguaensis*, represented by a population with around 1,000 individuals in El Tapado (north of the country), and *O. b. uruguayensis*, with less than 350 individuals, located at Los Ajos in southeastern Uruguay (GONZÁLEZ *et al.*, 2002). While the other subspecies (*O. b. leucogaster*, *O. b. bezoarticus* and *O. b. celer*) have some populations in protected areas in

Argentina, Bolivia and Brazil, the Uruguayan populations are located only in private lands in which diverse agricultural activities are conducted (JACKSON *et al.*, 1980). Even though pampas deer have been recognized by the Uruguayan government as threatened, declaring the species a living Uruguayan Natural Monument (Ministerial Decree 12/985), no management guidelines have yet been issued, nor any action taken to its effective conservation.

The study of the diet of a species is important to understand the relationships of niches, competition, predation and the impact of the species exercise on natural and cultivated ecosystems (DEBLASE & MARTIN, 1981). To understand niche selection and habitat utilization it is necessary to understand the way animals resolve, at present and throughout their evolutionary history, the conflicts between the need for food and the intrinsic and extrinsic constraints they face (ILLIUS & GORDON, 1993).

Microhistological techniques for determining food habits of large herbivores can be biased by differential digestibility of plant epidermis as it passes through the

digestive tract of a ruminant. However, fecal analysis is widely used for describing diets of wild and domestic herbivores (TODD & HANSEN, 1973). It is often the only practical method available, particularly with some rare or endangered wild herbivores on which collecting ruminal samples is not possible (GONZÁLEZ & DUARTE, 2007).

HOFMANN & STEWART (1972) classified mammalian herbivores, along a continuum according to which plant type they prefer, as: bulk and roughage feeders or grazers, that select diets containing < 25% browse; concentrate selectors or browsers, that select diets containing at least 75% fruits, dicotyledonous foliage, and tree and shrub stems and foliage; or intermediate or mixed feeders, that select both grasses and browses. Diet choices correspond with morphological specialization of the gastrointestinal tract, which may confer increased efficiency for extracting nutrients from grasses and browse. Browse and grass differ in the proportion of cell contents (entirely digestible), digestible cell wall and an indigestible residue (lignin). The first have higher levels of cell contents and lignin and the grasses contain higher levels of cellulose and hemicellulose. Therefore, browsers are expected to have a digestive system adapted for the rapid excretion of the highly lignified, less digestible cell wall fraction, while grassers have adaptations to slow down the passage of plant material in the rumen, thereby increasing the extent of digestion of the less lignified cell wall component (GORDON & ILLIUS, 1994).

Understanding the feeding niche of a species in particular, may help to recognize diverse interactions and proper range management (SHIPLEY, 1999). Free ranging herbivore management plans should consider different spatial patterns of vegetation types and uses, as well as the “artificial” manipulation of productive areas (GORDON, *et al.*, 2004).

Feeding studies has been conducted in *O. b. celer* pampas deer populations from Argentina (JACKSON & GIULIETTI, 1988) and in Brazil in the subspecies *O. b. leucogaster* in the Brazilian Pantanal (PINDER, 1997); and in *O. b. bezoarticus* in the cerrado (RODRIGUES & LEITE DE ARAUJO, 1999). Until now pampas deer feeding strategies have not been analyzed in the context of a modified habitat with both, livestock and different kinds of crops. As part of a longer-term research to obtain information for the development of adequate conservation management plans, this study aims at obtaining baseline information to assist comprehension of their (deer / agriculture / livestock) relationships. We attempt to determine the interaction processes of pampas deer and plant communities in Uruguay. We performed an ecological study based on monitoring the Los Ajos population, and we describe the feeding niche of the pampas deer in a modified habitat. The main points examined are the plant species consumed by the deer, the feeding strategy (grazer or browser) corresponding to pampas deer and estimated the spatial overlapping with sympatric livestock.

## MATERIAL AND METHODS

The study area of the Los Ajos population is mainly located in a ranch of 8,000 ha (33°50'01”S; 54°01'34”W) within the “Bañados del Este” Biosphere Reserve, Rocha

Department in the southeast of the country. The area used by the deer is estimated to be 2,500 ha. The main activities are livestock (cattle and sheep ranching) and the main crops are rice for human consumption and ryegrass (*Lolium* sp., Poaceae) for pasture. The pampas deer is free ranging in this complex scenario of discrete patches with different kinds and amounts of livestock and crops.

The landscape is low, rolling hills; the parent material consists of Quaternary unconsolidated sediments (clays, argillaceous muds and sands and, locally at rocky points, igneous or metamorphic rocks). The soils are predominantly gleysols. Altitudes ranging from - 5 to 100 masl, the annual average rainfall is 1,000 mm and the average annual temperature is 16°C (RAMSAR SITES DATABASE, 2003).

Field trips were made to the study area in May (autumn), July (winter), September (spring) 1998 and January (summer) 1999, thus covering every season of the year. The number of animals (pampas deer, cattle and sheep) per enclosure was estimated by road counts using a pick-up truck through fixed routes with an extension of 8 km with an average duration of 3 hours. In the areas with greater density of pampas deer four 100 x 10 m transects were established. Vegetation was sampled within 16 randomly selected 30 x 30 cm plots within each transect. Additionally we collected fresh pampas deer faeces corresponding to, at least 10%, of the deer counted in each sample period.

Plant species were identified for each of the plot samples collected. This provided a taxonomic list of species occurrence, as well as a reference herbarium for the area. Specimens were grouped by species or genus. In most cases collection of flowering plants was not possible thus, identification was based on vegetative characteristics which often meant that specimens were identified only at the genus level. Dry weight and relative biomass was estimated for each species/genus.

Botanic composition of the pampas deer’s diet through a year was evaluated from faeces by means of a microhistological technique. The protocol used was developed based on ZYZNAR & URNESS (1969) TODD & HANSEN (1973), PUTMAN (1984), GREEN (1987). Briefly, fresh droppings were preserved separately in plastic bags; oven-dried at 60 °C, grounded in a mortar, dissolved in water and treated in various solutions. The samples were then soaked in alcohol and stained with safranin. Samples were transferred to slides and mixed with Hoyer’s mounting medium. Five slides of each fecal material were examined under a binocular microscope at a magnification of 100X and twenty microscope fields per slide, located systematically. We examined the frequency of occurrence of recognizable plant fragments for each sample. The identification of the fragments was based on different features and dimensions of the epidermal cells and other valuable taxonomical structures (e.g. trichomes, stomata form). The taxonomical classification was performed considering two groups of plants (monocotyledon and dicotyledonous), trying to identify the family, genus, and species.

Habitat use and selection was measured considering: 1. Use (pi): the percentage of the i-th species

category observed on feces on all droppings that were recorded in the samples (KREBS, 1989); 2. Morisita's index (C) (WOLDA, 1981) for spatial overlap:

$$C = 2 \sum P_{ij} P_{ik} / \sum P_{ij} [(n_{ij}-1)/(N_j-1)] + \sum P_{ik} [(n_{ik}-1)/(N_k-1)]$$

where  $p_{ij}$  and  $p_{ik}$  are the proportion of the total resource used by deer and cattle (or sheep), respectively, allocated to the  $i$ -th category of a given resource dimension (e.g. different enclosures),  $n_{ij}$  and  $n_{ik}$  are deer and cattle (or sheep) numbers to the  $i$ -th category of a given resource dimension respectively (the category was taken equivalent to vegetation type and enclosure), and  $N_j$ ,  $N_k$  are the total numbers to each species on the sample. This index measures the proportion of the spatial overlap, and assumes values between zero (total niche separation) and one (total overlap). This index was applied for each season.

3. Levin's (KREBS, 1989) index was used for niche breadth.  $B = 1/\sum p_j^2$

where  $p_j$  are the proportion to the  $i$ -th category of a given vegetal resource on feces; HULBERT (1978) suggests the following measure for standardized niche breadth:

$$B_A = B/n - 1$$

where  $n$  is the number of possible resource states; this index assumes values between zero and one; 4. Ivlev's index (KREBS, 1989) was used for electivity.

$$E_i = r_i - n/r_i + n_i$$

where  $r_i$  is the proportion to  $i$ -th species on feces and  $n_i$  to  $i$ -th species on habitat. This index varies from -1 to +1, with values between 0 and +1 indicating

preference and values between 0 and -1 indicating avoidance. We use this index to compare the selection of crops (rice and ryegrass).

Statistica software (STATSOFT, 1995) was used for statistical analyses. Significant differences were considered at  $P < 0.05$ . PEARSON'S correlation (1896) was used to analyze food offer (what was available in the field) and diet (what was actually found in the faeces). Pearson's correlation was also used to look at the relationships between niche breadth, spatial overlap with cattle, and the Uruguayan mean of vegetation productivity.

## RESULTS

Species diversity offer and diet. The main food offer on the studied year consisted of crops (ryegrass and rice), we identified 56 plant species/genera. The monocotyledons were dominant in all samples, with proportions of 82% in autumn, 97% in winter, 98% in spring and 73% in summer.

The species diversity on faeces was composed mainly by ten genera that represented 86% of the total sampling. The remaining 14% was composed by species with occurrence values under 0.05% and were considered traces. Monocotyledons were observed more frequently than dicotyledons except for the summer period (Tab. I).

The results of Pearson's simple correlation analysis showed a strong correlation between the type of plant

Table I. Mono and dicotyledon plants relative abundance found in *Ozotoceros bezoarticus* Linnaeus, 1758 feces at Los Ajos from May 1998 to January 1999 (\*, only traces detected).

	Family	Fall 98	Winter 98	Spring 98	Summer 99
Dicotyledons species					
<i>Baccharis trimera</i>	Asteraceae	*	*	*	*
<i>Dichondra</i> sp.	Convolvulaceae	*	*	*	*
<i>Digitaria</i> sp.	Poaceae	*	*	*	*
<i>Eleocharis</i> sp.	Cyperaceae	*	*	*	*
<i>Gamochaeta</i> sp.	Asteraceae	*	*	*	*
Malvacea					
<i>Myriophyllum brasiliensis</i>	Haloragidaceae	*	*	*	*
<i>Plantago</i> sp.	Plantaginaceae	0.295	0.099	0.003	0.241
<i>Rhynchospora</i> sp.	Cyperaceae	*	*	*	*
sp. 15		0.017	0.048	0	0.01
sp. 210		0	0	0	0.051
sp. 250		0	0	0.013	0.18
sp. 300		0	0	0	0.061
sp. 31		0.028	0.024	0	0.071
Other dicotyledon		0.02	0.039	0.004	0.046
Total dicotyledon		0.36	0.21	0.02	0.66
Monocotyledons species					
<i>Briza minor</i>	Poaceae	*	*	*	*
<i>Bromus cathauticus</i>	Poaceae	0.011	0.024	0.08	0.003
<i>Cynodon dactylon</i>	Poaceae	*	*	*	*
<i>Lolium</i> sp.	Poaceae	0.06	0.158	0.328	0.017
<i>Oriza sativa</i>	Poaceae	0.224	0.226	0.067	0.099
<i>Poa</i> sp.	Poaceae	0.013	0.014	0.145	0
<i>Sisyrinchium</i> sp.	Iridaceae	*	*	*	*
Other monocotyledon		0.332	0.368	0.36	0.221
Total monocotyledon		0.64	0.79	0.98	0.34
Total		1	1	1	1

(mono and dicotyledon) in the field (offer) and that found in the faeces (intake) ( $r = 0.95$ ;  $p = 0.049$ ).

Main crop incidence and preference. Rice consumption showed similar values for the autumn (22.43%) and winter (22.58%) samples, and then fell to 6% and 9% for the months of spring and summer respectively. The consumption of ryegrass increased in July (15.82%) and September (32.81%) and decreased in May (5.98%) and January (1.7%). The electivity index (or Ivlev's index) obtained for rice and ryegrass are detailed on table II.

Spatial overlap with livestock. Values obtained for spring and autumn suggested a large spatial overlap with cattle. However, for winter and summer this index showed a lower value. The Morisita Index with sheep exhibited only one overlap recorded in winter, while in the other seasons there was a total spatial exclusion (Tab. III).

The niche breadth index values (Tab. III) were significantly correlated with the overlap levels with cattle ( $r = -0.98$ ;  $p = 0.02$ ); while the pastures average productivity values taken from PUERTO (1969) did not show significant correlation with any of the before mentioned variables (Fig. 1).

Table II. Electivity index for crops: ryegrass (*Lolium* sp., Poaceae) and rice (*Oriza sativa*, Poaceae). This index varies from -1 to +1, with values near +1 indicating preference and values close to -1 indicating avoidance, values around 0 indicating consume related with resource offer.

Specie	Autumn 98	Winter 98	Spring 98	Summer 99
<i>Lolium</i> sp.	-0.234	0.242	0.545	-0.647
<i>Oriza sativa</i>	-0.155	-0.152	-0.640	-0.621

Table III. Habitat overlapping between selected pairs of herbivores in Los Ajos, the degree of habitat overlapping is higher when the value is closer to 1.0; and standardized deer niche breadth.

Season	Habitat overlap		Deer niche breadth
	Deer and cattle	Deer and sheep	
Autumn 98	0.765	0.000	0.35
Winter 98	0.322	0.057	0.43
Spring 98	0.949	0.000	0.29
Summer 99	0.136	0.000	0.52
Yearly average	0.543	0.01425	

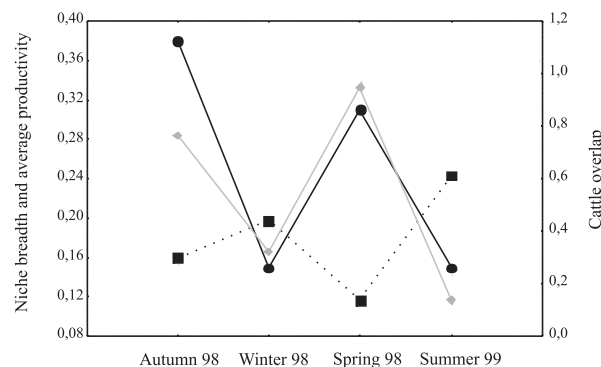


Figure 1. Values obtained for *Ozotoceros bezoarticus* Linnaeus, 1758 niche breadth (■ left axis), spatial overlap by cattle and deer (◇ right axis) and average of Uruguayan vegetation productivity (● left axis).

## DISCUSSION

Pampas deer feeding niche and main crops. The proportion of grass-browse (i.e. monocotyledons - dicotyledons) consumed by pampas deer in Los Ajos varied throughout the year. In the winter and spring samples we observed a high intake of graminoid species and less than 25% browse (dicotyledons) in the diet, a typical grazer behaviour.

The data observed on the other two sample periods (summer and autumn) show a behaviour corresponding to an intermediate or mixed feeder, with values for dicotyledons corresponding 36% of the plant species recorded in the faeces in autumn, and 66% in summer.

Pampas deer diet has been described for other populations in Argentina (JACKSON & GIULIETTI, 1988) and Brazil (RODRIGUES & LEITE DE ARAUJO, 1999). The Argentinean pampas deer populations consume mainly grass (JACKSON & GIULIETTI, 1988). The San Luis population was considered by JACKSON & GIULIETTI (1988) as "selective feeders", depending heavily on green forage all year, and described (based on HOFMANN & STEWART, 1972) as "concentrate selectors". MERINO (2003) classified the pampas deer from the Campos Tuyú Wildlife Reserve, Argentina, as a mixed grass feeder with a mixed diet and a preference for grasses. On the other hand, RODRIGUES & LEITE DE ARAUJO (1999) detected pampas deer selecting forbs, instead of the more abundant grasses in the habitats of the Brazilian Cerrado. Finally, PINDER (1997) observed that pampas deer in the Brazilian Pantanal did not consume grasses or forbs preferentially all year around as expected. This author suggests that pampas deer selected new growth despite the food category and can be considered as a "concentrate selector" (*sensu* HOFMANN, 1988). In Los Ajos population from Uruguayan grassland the analysis showed a mixed diet and a preference for grasses, being classified like "mixed grass feeder" according to HOFMANN (1988).

These different feeding strategies can be explained considering the phytogeographical variation throughout the pampas deer's range. The Uruguayan and Argentinean habitats have a predominance of temperate grasslands. Here the grasses and dicotyledons are three-carbon compound (C3), different from the rough tropical (C4) vegetation dominant in the Cerrado, which trend to exhibit high dry weight accumulations that are often of low nutritive value (VAN SOEST, 1982). In the Pantanal the phenological succession of the vegetation seems to correspond with three main "seasons": rainy, flood and dry (PINDER, 1997).

Considering the overall scenario, pampas deer is characterized by an opportunistic foraging strategy typical of intermediate or mixed feeders. HOFMANN (1989) described this group as one with a marked degree of forage selectivity, and a mixed diet, avoiding fibre as long and as much as possible, accepting a broad range of items including grasses, herbs, leaves, flowers, depending on the phenological characteristics of the different habitats in which they occur.

The results of this study show that the opportunistic feeding behaviour is also related with crop resources in relation with their phenological development (ryegrass) and abundance (rice).



According to LYONS *et al.* (1996) the degree to which a ruminant can adapt to different diets is related to its feeding type, which is determined by its digestive anatomy. While there is no published data on the anatomy and measurements of the digestive system of pampas deer, during a necropsy of a female in October 2002, we observed the following measurements: body length 79.7cm; total intestine length: 1,569 cm; large intestine: 470 cm and small intestine: 1,099 cm.

Typical grazers have total intestine length 25-30 times body length. For browsers this value is around 12-15 times body length (HOFMANN, 1989). The data taken from specimen above mentioned showed an intermediate range of 19.8 times its body length. This supports its classification as an intermediate feeder. However, the proportion length of large intestine and small intestine to total intestine was, respectively, 29.8% and 70.2%. These values, according to HOFMANN (1989), fall within the range of browsers (27-35% and 65-73%). The patterns are identical to those observed for Mongolian gazelles *Procapra gutturosa* (Pallas, 1777) (JIANG *et al.*, 2002). These authors suggest that these proportions tell us about an important distal digestion for small intermediate feeders with a strategy similar to that of browsers, possibly due to their small body size.

Spatial overlap with sympatric livestock. We observed differential spatial overlapping rates with the cattle, sheep and seasonality. During our study, we observed that the spatial overlap of deer and sheep was very low or non-existent. These results may indicate a degree of competition, which is defined as the use of a resource (in this case space or enclosures) by an individual or species, which leads to a reduced availability of the resource for other individuals or species (DUNBAR, 1978). The spatial segregation is probably a consequence of the level of competition, which would arise from their similar body mass and/or feeding strategy. BODMER (1991) has observed for Amazonian ungulates that those species that have similar diets use different habitats.

The relation between deer and cattle in the use of space at Los Ajos varies seasonally; we observed a greater spatial overlap in Autumn and Spring, while in winter and summer it decreases. As PUTMAN (1996) clearly states, the evidence of overlap in the use of a resource is not evidence for competition. This kind of process was explained by BOER & PRINS (1990). These authors consider that a large overlap is a sign of non-problematic coexistence between individuals of different species, which do not need segregation to satisfy their requirements. Furthermore spatial overlap in some cases, may be one of mutualism. This kind of association was suggested on the succession of grazing ungulates from Serengeti National Park by SINCLAIR & NORTON-GRIFFITHS (1982). According to GORDON (1988), summer grazing by cattle has shown to increase the quality of grass swards available for red deer hinds on the Isle of Rum.

Following the above line of thought, the high level of spatial overlap observed between pampas deer and cattle, indicates that there must be a low level of competition for food. This idea was confirmed in San Luis, Argentina and Pantanal, Brazil, where JACKSON & GIULIETTI (1988) concluded, based on analysis of diet

overlap that cattle and pampas deer do not compete for food.

The relation between pampas deer and cattle in Los Ajos is probably due to the use that pampas deer make of the ryegrass resource, which is grown to feed the livestock. While cattle are restricted to their particular enclosure, pampas deer can move freely between enclosures and go to where they find the highest-quality food. High levels of overlap were observed in enclosures where the ryegrass was more palatable.

The values obtained for Levin's niche amplitude index showed a negative correlation with the levels of space overlap with cattle, suggesting that at greater space overlap, smaller indexes of niche amplitude will be found, and vice versa. This was related with the fact described above: when the ryegrass was more palatable pampas deer consume mainly this grass, and so we observed low diversity on the diet and high overlap with cattle. Whereas when this grass drops in its nutritional quality pampas deer leave the areas looking for other sources of food, increasing their diet diversity and decreasing the space overlap. This was clearly shown in the summer samples when a high diversity of species principally composed of annual plants was observed on the diet.

Implications for management and conservation. Pampas deer is threatened in Uruguay, with fewer than 1,200 individuals. The population decline was due to habitat and population fragmentation, and unregulated hunting. Specially at the beginning of the last century as part of "control" efforts by ranchers who believed that deer competed with livestock. The foraging behaviour of pampas deer observed throughout its range is opportunistic with a considerable potential for use of marginal land.

We can consider two desirable (non-mutually exclusive) scenarios to conserve pampas deer populations in Uruguay: The first is the creation of protected areas representing the natural grassland landscape (nonexistent today) including the deer. The other is conciliation between agricultural development and conservation. An option is to offer incentives to the landowners with wild populations. This would stimulate the implementation of management plans for the conservation of wildlife, while being compensated for the losses caused by a reduction in productivity. For this, it is extremely important to be capable of predicting what will happen with the wild populations in response to imposed environmental changes (SUTHERLAND, 1998).

Currently neither of these alternatives is being implemented. Thus the habitat of the pampas deer and all the natural grassland communities are in a very fragile condition. Whatever protection they have depends on the good will of the owners of the land and on their individual capacity to meet the costs of maintaining these wild populations.

This work shows that the presence of pampas deer and certain agricultural activities are compatible as long as some management standards are set, especially related to the density of cattle and extent of the area of some monocultures. Various management practices could be implemented to ensure the growth and sustainability of pampas deer populations.

Habitat use and food selection by pampas deer are regulated by three main variables: density of the cattle, the total food offer in the different (neighbouring) enclosures and seasonal variation in the productivity of the pastures.

In relation to the density of livestock, we must emphasize that the presence of sheep in an enclosure significantly reduces its use by pampas deer. Density of cattle should be cared for, especially in the cold (Winter) and dry (Summer) months.

Ryegrass pastures are used by the deer. They are a good nutritional complement, especially during the winter months, and can be shared with cattle at average densities. It is important to emphasize the important contribution of natural grasslands especially during the Summer, when the major nutritional components of crops are in decline. Rice crops should not be established in large areas, as they are preferred not a food item by the deer.

According to the information that we obtained during this study the role of the landowners of establishments with wild populations is very important. This circumstance emphasizes the need to implement a system in which the State can offer incentives and compensations to the owners.

A key factor in ensuring the survival and recovery of these threatened populations is the dissemination of ecological information on pampas deer at all organizations, ranging from scientific institutions to government agencies, with capacity to support and implement management policies.

The recent demographic history and the degree of genetic variability that maintains one of our last populations of pampas deer, shows that the species still has a good potential for recovery. Pampas deer have the genetic and ecological potential to exist over a much greater area and historical data demonstrate a wide distribution for the species (GONZÁLEZ, *et al.* 1998). If the conservation goals are to maintain stable populations in the long term, conservation efforts should focus on strengthening and protecting the quality of the habitats and establishing management guidelines for pampas deer habitats on a large geographic area.

**Acknowledgments.** Special thanks to Ing. Ag. Mauricio Bonifacino, Herbarium Assistant curator from Facultad de Agronomía, UdelaR, who performed the taxonomic classification of the material collected in our reference herbarium, Dr. Mariano L. Merino from La Plata Museum for technical assistance, and for assistance in the field work aid Alejandro Márquez, Alejandra Pacheco, Silvia Villar and Marcelo Giloca. We also acknowledge Dr. Sonia Gallina, J. M. B. Duarte and an anonymous reviewer for the critical and valuable suggestions that greatly improved the quality of this manuscript. This research was partially supported by PEDECIBA, Comisión Sectorial de Investigaciones Científicas-UdelaR from Uruguay (Projects "Biología y Conservación de Cervidos Neotropicales" and "Monitoreo *in situ* y caracterización genética de venado de campo"), and Wildlife Trust Alliance. Thanks to Uruguayan ranchers landowner to authorized field work Mr. C. Arrarte, J. P. Castro, G. Constantin, and F. Estima.

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