



**NORTH – WESTERN JOURNAL OF ZOOLOGY**  
*(International journal of zoology and animal ecology)*

# ACCEPTED PAPER

**- Online until proofing -**

Authors: María Belén SEMEÑIUK; Mariano Lisandro MERINO

Title: Behavioral responses of the pampas deer (*Ozotoceros bezoarticus*) to human disturbance in San Luis province, Argentina

Journal: North-Western Journal of Zoology

Article number: e162701

Status: awaiting English spelling editing  
awaiting proofing

How to cite:

Semeñiuk M.B., Merino M.L. (2016): Behavioral responses of the pampas deer (*Ozotoceros bezoarticus*) to human disturbance in San Luis province, Argentina. North-Western Journal of Zoology (2016): e162701

Date published: <2016-06-26>

1 **Behavioral responses of the pampas deer (*Ozotoceros bezoarticus*) to human disturbance**  
2 **in San Luis province, Argentina**

3 María Belén SEMEÑIUK<sup>1,2,\*</sup> and Mariano Lisandro MERINO<sup>3,4</sup>

4 1. Anexo Museo de La Plata, Universidad Nacional de La Plata, 122 y 60, La Plata, 1900,  
5 Buenos Aires, Argentina.

6 2. Consejo Nacional de Investigaciones Científicas y Técnicas.

7 3. Centro de Bioinvestigaciones, Universidad Nacional del Noroeste de la Provincia de  
8 Buenos Aires, CIT-NOBA, Ruta Provincial 32 Km 3.5, Pergamino 2700, Buenos Aires,  
9 Argentina.

10 4. Comisión de Investigaciones Científicas de la provincia de Buenos Aires.

11 \*Corresponding author, M.B. Semeñiuk, Email: mbelen\_semeniuk@fcnym.unlp.edu.ar

12

13 **Abstract:** Pampas deer (*Ozotoceros bezoarticus*, Linnaeus 1758) is a South American cervid,  
14 associated with grasslands and savannas; in Argentina this species is listed as “endangered”.  
15 Our aim was to analyze the behavioral responses of the pampas deer to human presence, and  
16 to evaluate possible effects of their poaching. We recorded behavioral responses from 382  
17 pampas deer groups during eight vehicle surveys, in “El Centenario” ranch (San Luis  
18 Province). Data were analyzed using the G-test of independence and logistic regression.  
19 Almost half of the groups (48.17 percent) remained on site. Behavioral responses differed  
20 significantly according to group size and composition and observer distance; being this last  
21 the variable most influencing flight, groups were more likely to flee at shorter distances. In  
22 return, behavioral responses were independent from habitat type, transect type and season.  
23 Our results suggest certain human tolerance and that consequently, poaching would not have  
24 important effects on this population.

25  
26 **Key words:** pampas deer, distance to observer, group size-composition, human tolerance,  
27 poaching.

28  
29 **Running title:** Behavioral responses of pampas deer

## 30 **Introduction**

31 The pampas deer (*Ozotoceros bezoarticus*, Linnaeus 1758) is an endemic South  
32 American species typical of open environments (Merino et al. 1997). This species was widely  
33 distributed, but in the early 20th century their populations suffered a strong numerical and  
34 geographic reduction (Demaría et al. 2003), due to habitat modification and increasing  
35 hunting pressure (González et al. 2010). Pampas deer is considered “near threatened” (NT)  
36 according to the IUCN Red List (González & Merino 2008), but in Argentina it is listed as  
37 “endangered” (Pastore 2012).

38 In Argentina, pampas deer inhabited a wide distribution area (Jackson 1987), however  
39 today only four isolated populations remain (Miñarro et al. 2011). This study was focused on  
40 the population of San Luis, where agricultural activities increased since the 1990s;  
41 nevertheless the population size in the distributional nuclear area was not affected by the  
42 intensified farming activity (Merino et al. 2011). This species has maximum protection;  
43 although their hunting is prohibited in the area, local residents report poaching on the paved  
44 roads (Miñarro et al. 2011).

45 The goal of this paper was to analyze the behavioral responses of the pampas deer in  
46 San Luis when they detected the presence of an observer, and to evaluate the possible effects  
47 of poaching.

48

## 49 **Materials and methods**

### 50 **Study area**

51 The population of San Luis inhabits the semiarid Pampean grasslands, a graminaceous  
52 steppe with small chañar (*Geoffroea decorticants*) patches (Anderson et al. 1970); 80% of  
53 annual precipitation falls between October and April (Berton & Echeverria 1999). “El  
54 Centenario” cattle Ranch where this study was accomplished hosts the largest pampas deer

55 nucleus of San Luis (Dellafiore et al. 2003). Currently, only 18% of the ranch has natural  
56 grasslands, whereas the exotic digit grass (*Digitaria eriantha*) and african lovegrass  
57 (*Eragrostis curvula*) occur in the rest of the grasslands; there are also small patches of crops  
58 (Merino et al. 2009, 2011).

59

## 60 **Analysis of the behavioral response**

61 Eight terrestrial surveys were conducted from a vehicle (30 kmh<sup>-1</sup>) along seven fixed  
62 transects variable in length (10-38.4 km), defined on the distribution of paved and dirt roads.  
63 Each transect was traveled once per survey, covering a total of 136.5 km. The eight surveys  
64 were performed in January and April 2010, 2011 and 2012 (coincident with rutting peak),  
65 November 2010 and October 2011 (birthing peaks) (Ungerfeld et al. 2008a, b).

66 We recorded group size and composition; group was defined following Netto et al.  
67 (2000). Four types groups were defined according to their composition: juveniles; adult  
68 males; adult females, with or without fawns/juveniles; and mixed, with or without  
69 fawns/juveniles. The age-sex classes follow Moore (2001).

70 Three possible behavioural responses were defined according to the attitude of groups  
71 when detecting our presence: -flee: immediately run away; -walk away: slowly moved away;  
72 -remain: stayed in the place doing their activities. The distance from the center of the group to  
73 the line transect was calculated using a rangefinder. In addition, we also recorded habitat and  
74 transect type.

75 Frequency of response was tested through a G-test of independence (Zar 1999),  
76 analyzing the group behavior depending on the distance to observer, group composition,  
77 group size, habitat type, transect type and season. For analyses, responses -walk away and -  
78 remain were aggregated. Then, to assess if particular variables deviated from their expected  
79 values, the adjusted residuals of each cell were examined (Agresti 2002).

80 Lastly, groups responses (0: no response, 1: flight) were analysed with logistic  
81 regression, considering all the main factors simultaneously. We can not ensure independence  
82 of the data; therefore this represents a limitation in our study.

83

## 84 Results

85 We observed a total of 382 groups, with an average of 47.75 groups per survey  
86 (1SD:12.82,  $n=8$ ). Remain was the behavioral response most used (48.17%), followed by flee  
87 (32.46%). Flight responses occurred at a mean distance of 80.23 m (1SD:58.03,  $n=124$ ) from  
88 the vehicle, in contrast to sighted groups that did not flee (120.54 m, 1SD:28,  $n=258$ ).

89 The group response when detecting our presence, according to their size and  
90 composition, transect type, habitat type, season and distance to observer is shown in Table 1;  
91 groups tended to remain in all situations. Response differed significantly among groups of  
92 different size ( $G=12.347$ , 3DF,  $p=0.006$ ), with solitary individuals fleeing more and  
93 staying/walking less than expected, and with groups  $\geq 4$  staying/walking more and fleeing less  
94 than expected (Table 2). Response was also dependent from group composition ( $G=16.18$ ,  
95 3DF,  $p=0.001$ ), females groups fleeing more and staying/walking less than expected,  
96 occurring the opposite in mixed groups (Table 2); principally during November 2010  
97 (females<sub>flee</sub>:62.5%, mixed<sub>flee</sub>:11.11%).

98 Significant differences were also found among distance to observer ( $G=16.244$ , 3DF,  
99  $p=0.001$ ), fleeing more than expected when distance range was 0–99 m and less than expected  
100 at  $\geq 200$  m (Table 2). On the other hand, behavioral response were independent from habitat  
101 type ( $G=2.804$ , 1DF,  $p=0.094$ ), transect type ( $G=1.566$ , 1DF,  $p=0.211$ ) and season ( $G=0.685$ ,  
102 2DF,  $p=0.71$ ).

103 The model logistic that best explained the response to observer included the distance,  
104 group size, and group composition (Chi-square=31.38, 9DF,  $p<0.0001$ ), being the distance

105 range the variable most influencing flight (200-299m:  $p=0.031$ ;  $\geq 300$ m:  $p=0.023$ ) with a  
106 strong negative influence on flight.

107

## 108 **Discussion**

109 Results showed that in our presence, most of the groups remained on site and continued  
110 performing normal activities. The reaction of individual may differ depending on their  
111 habituation to disturbance, animals habituated to humans did not flee, even at very close  
112 distance (Recarte et al. 1998); this suggests that pampas deer accustomed to humans reacted  
113 less often to presence of observer. However, probably the individuals less reactive were  
114 recorded more times than the more reactive ones; therefore, probably a greater percentage of  
115 animals are reactive. There are differences between responses of pampas deer populations  
116 according to human activities. For example in Paraná (Brazil), the most frequent response to  
117 observer was fleeing (Braga et al. 2000); noteworthy, this population is “endangered” due to  
118 their small size and the existence of hunting episodes in the area (Braga & Kuniyoshi 2010).

119 According to Stankowich (2008) the tolerance to human is a predicted behavior for  
120 ungulates non-hunted; thus, hunted populations have significantly greater flight responses.  
121 This trend was observed among cervids in the white-tailed deer (*Odocoileus virginianus*)  
122 (Kilgo et al. 1998), elk (*Cervus elaphus*) (Bender et al. 1999) and reindeer (*Rangifer*  
123 *tarandus*) (Baskin & Hjältén 2001). Pampas deer hunting is prohibited in Argentina, however  
124 poaching still persists (Miñarro et al. 2011); our results suggest tolerance to man and that no  
125 episodes of poaching occur within of study area.

126 In this study, logistic regression results suggest that the distance to observer is the  
127 variable most influencing flight, fleeing more frequently the closest groups. Flight distance is  
128 the distance between animal and observer at the moment of flight initiation (Phillips 1993). It  
129 has been observed that ungulates under strong hunting pressure have longer flight distances

130 (de Boer et al. 2004). Consequently, the fact that the pampas deer responded fleeing of  
131 observer only to short distances, would be another evidence of that no poaching occur within  
132 “El Centenario”; because if it had been poached it would flee to higher distances.

133 Pampas deer behavioral response was also associated with their group size, solitaires  
134 individuals tending to flee and larger groups remaining (Table 2). This suggests human  
135 disturbance as a stressor that affects them mainly when they are alone. This was also observed  
136 in ungulate species in which groups took flight less often with increasing size (Malo et al.  
137 2011); i.e. individuals may react less in situations of greater security, thus the flight is less  
138 likely in large groups (MacArthur et al. 1982).

139 As well, the pampas deer response was linked with the group composition, with female  
140 groups fleeing mainly during birthing peak (November), seeking better protection for their  
141 fawn. Group patterns are also influenced by the life cycle according to the reproductive period  
142 (Semeñiuk & Merino 2015), which could also play an important role in their behavior. For  
143 instance, the variability among sexes in the flight could be linked to differences in their  
144 reproductive strategies; females prioritize the fawn survival, and are therefore more likely to  
145 react to a source of disturbance (Stankowich 2008). Moreover, Ungerfeld et al. (2015)  
146 observed that according to social status of pampas deer hinds differs their relationship with  
147 the man, high-ranked hinds avoided humans at greater distances. Likewise, the relationship  
148 between the hormonal status of males and the response to disturbance was studied in the  
149 Emas National Park, (Pereira et al. 2006): pampas deer inhabiting outside the Park (frequent  
150 human disturbance) present higher glucocorticoid concentrations (and stress), and exhibit  
151 higher flight distances, than the individuals inside the Park (lower human activity).

152 Thus, we conclude that most of the pampas deer groups remained on site; their  
153 behavioral response depended mainly of distances to observer, groups were more likely to  
154 flee at shorter distances. The poaching would not have important effects over this population;

155 however, we recommend installing police stations on paved roads to perform a more effective  
156 control.

157

### 158 **Acknowledgements**

159 We thank the staff of the “El Centenario” Ranch for their valuable help, especially Ag.  
160 E. Gonzalo Molina and Leonardo Benítez. This research was funded by grants from  
161 CONICET, Universidad Nacional de La Plata, CICIPBA, BBVA Foundation Spain and  
162 CREOI.

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262 **Tables**

263

264 **Table 1.** Behavioral response of pampas deer groups (%) when detecting the presence of an  
 265 observer, according to the group composition, transect type, habitat type, group size, distance  
 266 to observer, and season.

267

268 **Table 2.** Adjusted residual values of number of pampas deer groups realizing the different  
 269 behavioral responses, respect to: A: group size, B: distance to observer and C: group  
 270 composition, in “El Centenario” Ranch (General Pedernera Department, San Luis). Values  
 271 displayed in bold are significant at the level  $\alpha = 0.05$ .

272

273 Table 1

		Behavioral response		
		Walking/staying	Fleeing	Total
Group composition	Juveniles	52.94	47.06	100
	Adult males	65.52	34.48	100
	Adult females	60.61	39.39	100
	Mixed	81.42	18.58	100
Transect type	Dirt road	68.64	31.36	100
	Paved road	59.09	40.91	100
Habitat type	Grassland	64.06	35.94	100
	Crop	72.12	27.88	100
Group size	1	58.50	41.50	100
	2	68.07	31.93	100
	3	76.56	23.44	100
	$\geq 4$	80.77	19.23	100
Distance range	0 - 99	61.76	38.24	100
	100 - 199	71.43	28.57	100
	200 - 299	86.96	13.04	100
	$\geq 300$	91.30	8.70	100
Season	Autumn	69.44	30.56	100
	Spring	68.67	31.33	100
	Summer	65.16	34.84	100

274

275

276

277 Table 2

Group size	Walking/staying	Fleeing
1	<b>-2.983</b>	<b>2.983</b>
2	0.148	-0.148
3	1.690	-1.690
$\geq 4$	<b>2.192</b>	<b>-2.192</b>

278 A

Distance to observer	Walking/staying	Fleeing
0 - 99	<b>-3.099</b>	<b>3.099</b>
100 - 199	0.954	-0.954
200 - 299	<b>2.052</b>	<b>-2.052</b>
$\geq 300$	<b>2.511</b>	<b>-2.511</b>

280 B

Group composition	Walking/staying	Fleeing
Males	-0.458	0.458
Females	<b>-2.524</b>	<b>2.524</b>
Mixed	<b>3.754</b>	<b>-3.754</b>
Juveniles	-1.315	1.315

282 C

283