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Landscape correlates of the distribution of coypu *Myocastor coypus* (Rodentia, Mammalia) in Argentinean Pampas

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Abstract

The coypu is a rodent indigenous to aquatic habitats in southern South America, which is considered a pest where it has been introduced and a valuable furbearer resource within its native range. The objective of this study was to identify the main landscape correlates of coypu distribution in the Pampas. Previous studies provided two non-exclusive hypotheses: (1) if hunting pressure regulates coypu distribution, then coypu presence should decrease in areas with high human density, while (2) if resource availability determines coypu landscape patterns, then coypu presence should be high in flooded areas with low human management of plant communities, that is natural grasslands used for extensive cattle raising. We sampled signs of coypu activity and 11 associated environmental variables in 87 600-m transects distributed in 14 rivers and streams of the Pampas region. The first factor of the principal component analysis (PCA) was associated with the wide of the alluvial plain and the agricultural use of land, the second one with human density in the surrounding area. We applied a multiple linear model between the first three factors of the PCA and the proportion of positive transects per watercourse. Our results indicated that coypus are less frequently found in urban and semi-urban landscapes. We postulate that hunting pressure is the main cause of this negative association, which is consistent with previous studies conducted at smaller ecological scales.

Keywords: *Hunting effect, landscape features, nutria, spatial scales, species distribution*

Introduction

The coypu, *Myocastor coypus*, is a large caviomorph rodent indigenous to aquatic habitats of southern South America (Gosling & Baker 1991). Wild populations have established in Africa, Asia, Europe, and North America from escapes from fur farms and intentional releases for harvesting (Carter & Leonard 2002). Most of these introduced populations are considered a nuisance because they provoke financial losses, affect native species, transmit diseases and modify ecosystem dynamics (Carter & Leonard 2002; Bound et al. 2003). Native populations are reduced by commercial hunting, magnified by the absence of effective control (Baroffio et al. 1980; Bertonatti & Corcuera 2000). The coypu is one of the most intensively exploited native species of Argentinean wildlife, mainly because its fur constitutes an important economic resource for rural people and farmers (Bó et al. 1992; Colantoni 1993; Bertonatti & Corcuera 2000).

During the last decade several aspects of the ecology and behaviour of the coypu in its native habitat have been investigated (Guichón & Cassini 1999, 2005; Borgnia et al. 2000; D'Adamo et al. 2000; Guichón et al. 2003a,b,c; Túnez et al. 2005, 2009). At a local scale, grassland availability and human perturbations have been reported to be the main determinants of coypu distribution (Guichón & Cassini 1999). Guichón et al. (2003c) compared native and exotic populations and concluded that while in Europe the main factor affecting population dynamics is the winter climate, hunting pressure disrupts the rather stable environmental conditions in the Pampas. Genetic diversity of native populations was negatively correlated with hunting pressure and positively correlated with population size (Túnez et al. 2005). Guichón and Cassini (2005) concluded that the spatial structure of the environment influences the decisions made by hunters at a local scale, as previously reported (e.g. Bennett et al. 1994;

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Hofer et al. 1996; Smith et al. 1997; Brøseth & Pedersen 2000; Millner-Gulland 2001). Hunting pressure also affects the behaviour of native coypus. Where coypus are persecuted, individuals remain to forage close to water (Guichón et al. 2003a) and live in social groups, which share communal burrows, increasing the probability to be detected (Guichón et al. 2003b).

A preliminary study on the determinants of the large-scale distribution of the coypus along the River Luján, an important watercourse located of the Pampas Region, suggested that high coypu relative abundance is strongly associated with the width of the alluvial plain (Guichón & Cassini 2007). Lowlands prone to flooding have natural grasslands exploited mainly for livestock activity while in narrow valleys, human density is higher, as so as riverbank alteration and habitat fragmentation. Coypus living close to human settlements are expected to suffer strong hunting pressure (Guichón & Cassini 2005; Guichón et al. 2003c).

Guichón and Cassini (2007) proposed a complementary explanation for the relationship between coypu distribution and the width of the alluvial plain: the wider the plain, the higher is the quantity and quality of aquatic and semi-aquatic habitats available for coypus (Guichón et al. 1999).

We analysed the distribution of the coypu in relation to landscape features in 14 rivers and streams of the Pampas. The main aim of the study was to test two hypotheses on the landscapes correlates of coypu distribution in this region of Southern South America: (1) if hunting pressure regulates coypu distribution, then coypu presence should decrease in areas with high human density, while (2) if resource availability determines coypu landscape pattern, then coypu presence should be high in lowlands used for extensive cattle raising. The objective of this study was to verify which is the main factor affecting coypu distribution at landscape scale in the Pampas region.

Materials and methods

The study area is located in the north-eastern Buenos Aires province, Argentina, which is characterized by a smoothly undulating topography produced by the tributaries of the rivers Paraná and De La Plata (Ghersa & Leon 2001). The temperate, moist climate has a mean annual temperature of 16°C and rainfall of 1000 mm per year, with no apparent dry period (Soriano et al. 1992). Agriculture and livestock have extensively modified native grasslands of the Pampas Region (Ghersa & Leon 2001). Agricultural activities predominate with respect to extensive cattle raising, which mainly occurs on low-quality floodplains soils (SAGyP & CFA 1995). This region is also characterized by important industries and urbanizations, possessing broad road connections and a large number of inhabitants.

We digitized the river network by ArcView 3.2 (licensed by PRODITEL group, Universidad Nacional de Luján), through the visual interpretation of a digital satellite image (Landsat 5 TM, January 1994) and using complementary cartography (maps at 1:250,000, 1:100,000 and 1:50,000 scales and satellite images (Landsat TM, October 2002) supplied by the Argentinean Military Geographic Institute). Alluvial plains, which were easily delimited observing the 1994 satellite image, were classified as wide (>400 m) or narrow (<150 m) according to Guichón et al. (1999). We therefore obtained more than 50 15–25-km long segments of watercourses having either a wide or narrow floodplain, from which we randomly selected seven segments per type of alluvial valley (n = 14; Figure 1), in order to ensure the homogeneous sampling of both narrow and wide alluvial plains. Thus, surveys for signs of coypu activity and the associated environmental variables were carried out along 5–8, 600-m long transects per stretch, as to cover ca. 25% of the length of each stretch, for a total of 87 transects.

For each selected watercourse, we made land use maps of the surrounding area as to determine: (1) total length (in km) of the river or stream segment; (2) type of alluvial valley (0=narrow, 1=wide); (3) overall number of bridges: number of roads that crossed each watercourse segment; (4) bridges/km; (5) number of cities: number of cities within a 50 km radius around the watercourse segment; (6) distance (in km) to the nearest city: average of the minimal distance measured following the shortest route across public roads to the nearest city; (7) number of inhabitants: sum of residents of cities, neighbourhoods and villages within a 50 km radius around the watercourse segment (INDEC 2001); (8) land use changes/km: frequency of change in land use type along the watercourse segments divided by the length of the segments; (9) per cent area used for raising cattle; (10) urban areas (%); and (11) agricultural areas (%).

Between December 2003 and March 2004, surveys of coypu signs (single sampling) were carried out using the standard method for sampling riparian mammals (Mason & MacDonald 1986). The number of transects per watercourse was proportional to segment length. Coypu faeces were searched in a 10-m wide belt on both riverbanks, coypu activity being mainly restricted to a few meters from the bank (Doncaster & Micol 1989;

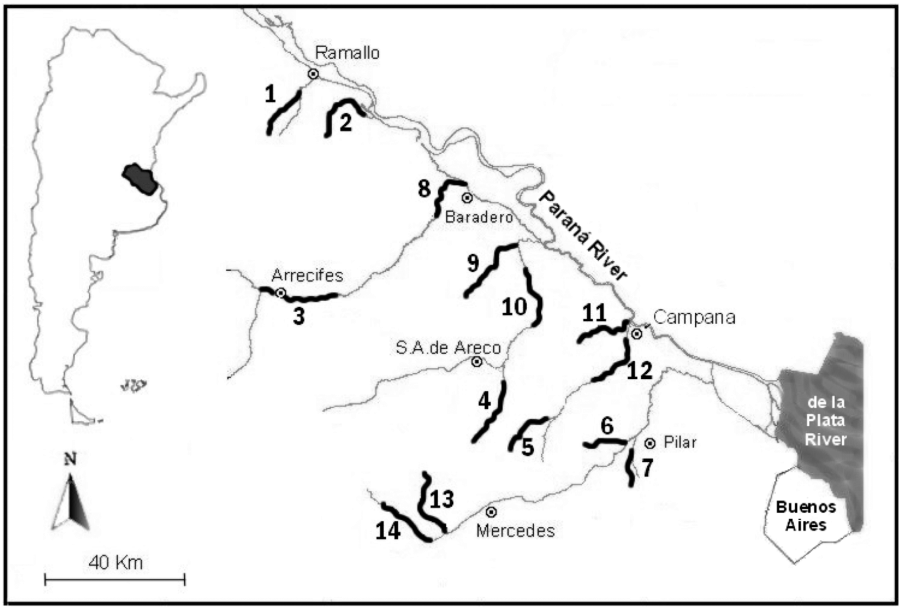

Figure 1. Study area in Argentina showing the location 14 rivers and streams studied and the most important cities and rivers. Rivers 1–7 have a narrow alluvial valley: (1) Las Hermanas, (2) Los Cueros, (3) Arrecifes, (4) Giles, (5) El Sauce, (6) Las Flores, and (7) Carabassa; while rivers 8–14 have a broad alluvial valley: (8) Baradero, (9) Cañada Honda, (10) Areco, (11) Pesquerías, (12) Cruz, (13) Moyano, and (14) Los Leones.

Borgnia et al. 2000; D'Adamo et al. 2000; Guichón et al. 2003a).

For each water segment, we calculated the proportion of positive transects (i.e. where coypu faeces were found). This method is more conservative for estimating wildlife relative abundance with respect to marking intensity (the number of faeces found per length), which is a method recently criticised in the literature (e.g. Gallant et al. 2007; Harrington et al. 2007). Bertolino and Ingegno (2009) recently highlighted the importance of modelling the distribution of coypu to determine habitat requirements of the species. They specifically used logistic regression to analyse the species distribution according to habitat attributes. Following a similar analytical strategy, we also used multiple regressions, with the difference that we firstly organised habitat variables in PCA (principal component analysis) axes, to avoid the risk of including correlated independent variables in the regression, a method widely used in previous studies (fur seals: Túnez et al. 2008a; sea lions: Túnez et al. 2008b; armadillos: Abba et al. 2007; otters: Aued et al 2003; mink: Fasola et al 2009; and coypus: Guichón & Cassini 1999).

PCA was performed to determine the relationship among the 11 variables described above in order to obtain orthogonal (independent) factors given the high correlation among some environmental variables. Variables with component loadings greater than 0.6 were considered to contribute significantly to the component. The first three factors of the PCA, explaining 80% of the variability of the data set, were used as independent variables in a multiple linear model (forward stepwise procedure), where the dependent variable was the proportion of transects positive for coypu signs in each watercourse, after arcsin of square root transformation to meet normality.

Results

The first factor of the PCA, which absorbed 42% of the variability of the data set, was negatively associated with frequency of land use change and agricultural activity and positively associated with the width of the alluvial valley and livestock activity (Table I; Figure 2). The second factor, which absorbed 27% of the variance, was negatively associated with the number of inhabitants and cities and percentage of urban areas, and positively associated with bridges (Table I; Figure 2). Factor 3 only explained 11% of the variance, and it was associated to the distance to the first city.

The multiple linear model using the first three PCA factors as independent variables showed that coypu occurrence is positively related to the second factor of the PCA ($F_{1,12}$ = 4.85, p = 0.047), but non-significantly related to the other two factors.

Table I. Loading values of 11 landscape variables for the three factors of the PCA analysis.

Variables	Mean	SD	Factor 1	Factor 2	Factor 3
Length (km)	3.73	0.58	0.37	0.36	−0.27
Valley	0.50	0.52	**0.89**	−0.26	0.02
Number of bridges	3.43	1.87	−0.41	**0.86**	−0.06
Bridges/km	0.18	0.10	−0.56	**0.76**	−0.06
Number of cities	2.57	0.76	−0.34	**−0.66**	0.33
Distance to the nearest city	4.57	3.59	0.38	0.03	**0.80**
Number of inhabitants	95,191	106,988	−0.48	**−0.76**	−0.06
Land use change/km	0.26	0.20	**−090**	−0.15	−0.14
% livestock raising area	43.43	22.77	**0.89**	0.06	−0.30
% urban area	7.64	7.81	−0.57	**−0.61**	−0.40
% agricultural area	46.64	19.16	**−0.84**	0.31	0.35
Explained variance			4.58	2.98	1.23
Proportion of total			0.42	0.27	0.11

Numbers in bold are statistically significant.

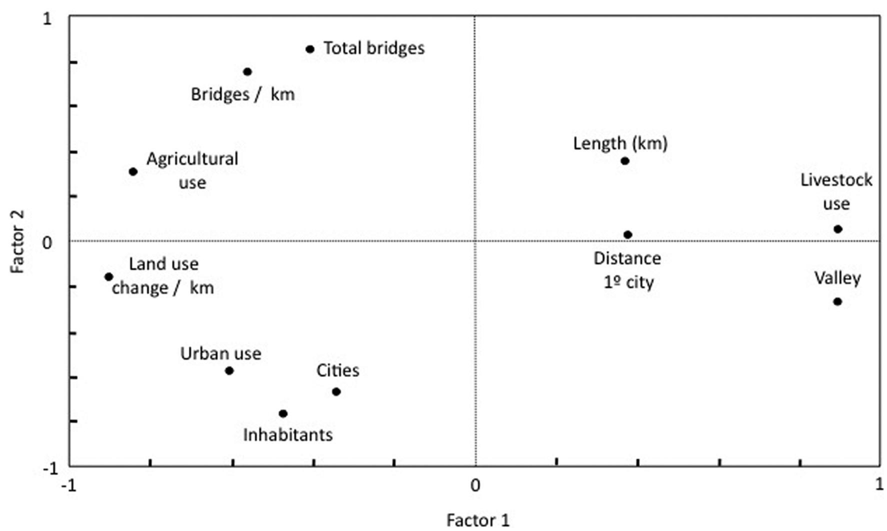

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Figure 2. Association among the variables and their contribution to the first two components obtained in the PCA.

Discussion

Guichón and Cassini (2007) analysed the distribution of coypus along a Pampean river, reporting that coypu heterogeneous distribution was simultaneously associated with three sets of variables that were highly correlated: (1) wide of the alluvial valley, (2) land use associated to resource availability, and (3) land use associated to human disturbance (i.e. hunting). At a wider scale, regression analysis indicated that the probability of finding signs of coypus decreased near cities and areas with large number of inhabitants, irrespective of the width and land use of the river valley. We postulate that hunting pressure is the main cause of this negative association. It is well known that coypus are tolerant of human presence and they can form stable populations even in urban and recreational areas, when they are not hunted (e.g. Meyer et al. 2005; Corriale et al. 2006). Therefore, it is not expected that human presence alone can decrease coypu abundance. However, we cannot discard the possibility that sub-optimal habitats that were not detected at the landscape scale may dominate in human-modified landscapes, thus making the presence of the species less stable. None the less, as suggested by previous studies conducted in Argentina (Guichón et al. 2003c; Guichón & Cassini 2005; Túnez et al. 2005) and in Europe (Gosling 1988; Doncaster & Micol 1989; Reggiani et al. 1993), the presence of areas with different hunting pressure may generate a source–sink dynamics. The flux of dispersing individuals from protected to hunted areas may explain the still relatively common records and wide distribution of the coypu in the region.

Coypu presence was also associated with bridges. This relationship could just be an epi-phenomenom of the effect of human perturbation, considering that bridges appeared to be built far from human settlements. Another possibility is that bridges are built in areas that possess some kind of benefit to coypus, as it occurs with other riparian mammals. For example, signs of otters (*Lutra lutra*) are frequently found under bridges because they probably represent effective marking sites for intra-species communication (reviewed by Gallant et al. 2008). There are no studies on the role of faeces as social marking in coypus.

An explicit consideration of spatial distribution of hunting pressure at an appropriate scale must be incorporated in harvest regulation policies. The most simple and widely used criterion for harvest regulation involves restrictions on the number and size of pelts and on the hunting period (close season), and policies for coypu harvest in Argentina are not an exception (SAyDS 2007). Explicitly delimiting protected areas that can serve as sources of individuals into hunting areas would improve sustainable harvest. These protected spots should be located in rather inaccessible areas and distant to cities, although connectivity through watercourses must be carefully evaluated to facilitate coypu dispersal into hunted, low-density areas. This strategy would integrate spatially explicit, large-scale consideration of heterogeneous distribution of coypu and environmental features.

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