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Population parameters of indigenous populations of *Myocastor coypus*: the effect of hunting pressure

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The coypu or nutria *Myocastor coypus* Molina, 1782 is a semiaquatic rodent intensively harvested for fur in its native region. We studied population parameters at four sites differing in hunting pressure and characterised hunting activity in north-eastern Buenos Aires province, Argentina. Our interviews with hunters, local inhabitants and wildlife managers revealed that hunting is a cultural tradition in the countryside with the coypu being used as meat and fur, and the young occasionally used as pets. Quarterly live trapping captured a high proportion of all coypus present at each site. In sites with higher hunting pressure, low density of coypus was associated with high population losses and immigration. In these sites the proportion of juveniles and pregnant females was similar to that obtained at sites with no hunting pressure. No foraging deficiencies were evident from diet quality analysis. Our results suggest that harvesting determines the dynamics of coypu populations in this region, where hunting pressure can be assessed by accessibility of hunting sites, their distance to urban or rural settlements, effective control of hunting, and human population density of the area.

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Introduction

The coypu or nutria *Myocastor coypus* Molina, 1782 is a large herbivorous rodent that inhabits different aquatic habitats in the southern cone of South America (Gosling and Baker 1991). Wild populations have been established in Africa, Asia, Europe, and North America mainly from escapes or releases from fur farms (Carter and Leonard 2002). In some areas where coypus were introduced, campaigns of eradication or control of their populations were undertaken because they are considered a threat to agriculture, drainage systems, and native flora and fauna (Gosling and Baker 1987, Reggiani *et al*. 1993, Bound *et al*. 2003). However, in its native range of Argentina the coypu is commercially the most important wild species of mammal in the furbearer market and is a major source of income for local

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inhabitants (Mares and Ojeda 1984, Bó *et al*. 1992, Colantoni 1993). Ninety-eight percent of commercial furs come from wild populations (Zaccagnini and Venturino 1993), yet there is no effective control over hunting permits and there exists a substantial illegal market (Bertonatti and Corcuera 2000). This fact led to over-exploitation of coypu populations in certain regions (Gosling and Baker 1991) resulting in the listing of coypu as a species that requires management programs for sustainable exploitation in Argentina (Holdo and García Fernández 1995). The importance of managing wild populations of coypu in this region becomes more evident given the widespread modification of the Pampas plains caused by intensified agricultural production and urbanisation (Cafiero *et al*. 2001).

In a previous study, we analysed the local environmental factors that were associated with coypu distribution in a typical riparian habitat of the Pampas region (Guichón and Cassini 1999). Coypu distribution was positively related to the availability of grasslands used for extensive livestock production and negatively related to local human perturbations and urban areas. Two possible hypotheses were proposed to explain this result: (1) favourable effects of the presence of lowland prairies that may provide an abundant and stable source of food and (2) detrimental effects of human activity, mainly hunting pressure, that may prevent population persistence. The first hypothesis was not supported by further studies on foraging behaviour and use of space by coypus (Borgnia *et al*. 2000, D'Adamo *et al*. 2000, Guichón *et al*. 2003a, b). These studies showed that individuals feed on vegetation available in the water and on the bank within 10 m of the water's edge. Coypus do not forage on the vegetation available in natural grasslands far from the bank, suggesting that they do not use the extra resources available in lowland prairies. However, no previous research has reported the effect of hunting pressure on indigenous populations.

Our objective was to analyse population parameters of four coypu populations in relation to hunting pressure. We also described hunting activity in the area through interviews of hunters, local inhabitants, and wildlife managers.

Study area

We performed research at four study sites located in the Pampas region, Province of Buenos Aires, east-central Argentina, from October 1999 to September 2000. Grassland steppe was the dominant vegetation, but natural vegetation has been widely modified due to livestock and agricultural practices, and urbanisation (Cabrera 1971, Bárbaro 1994). The climate is moist temperate: mean annual precipitation 944 mm, and mean temperature 23.8°C in January and 9.1°C in July (Goldberg *et al*. 1995).

The first study site (Ruiz) was a 1.5 km length of stream (2–15 m wide) that crossed three fields of cattle pasture (natural grasslands). The second site (Luján) was formed by two small ponds (0.6 and 0.08 ha) connected by a portion of stream ca. 100 m long and located in fields used for cattle grazing in the campus of the University of Luján. The other two sites (Jáuregui and Ratti) were located in a large field of cattle pasture and timber plantation. The Jáuregui site included a 4.3 ha pond and the Ratti site included two ponds (2.3 and 4 ha) connected by a canal ca. 200 m long. The ponds had been constructed for recreational purposes in 1960 by modifying natural watercourses and were connected with the Luján River by streams or canals. The minimum straight distance from Jáuregui (34°35'S, 59°11'W), which was somehow in the middle of the four sites, to Ratti was 4.5 km, to Luján was 11.5 km, and to Ruiz was 16 km.

Availability of green herbaceous vegetation was similar among sites throughout the study period (Guichón *et al*. 2003a). Dominant aquatic and terrestrial vegetation were *Lemna* and grasses, respectively, which are the main components of the coypu diet (Abbas 1991, Borgnia *et al*. 2000, Guichón *et al*. 2003a).

Material and methods

During preliminary campaigns conducted from January to August 1999, we mapped all burrows and sampled signs of coypu activity, which indicated that the study sites differed in coypu abundance. We also estimated hunting opportunity at each site by interviewing landowners, workers, inhabitants, and neighbours of each study site. Even if hunting was prohibited at all sites, only at Ruiz and Jáuregui were intruders expelled by the workers who lived close to the ponds and streams. Guards patrolled Luján at night, but there was no effective control during the day. Ratti was isolated from the houses located within the field and provided easy access for intruders. The owner and workers of the field admitted that they were unable to control this area. Therefore, sites were assigned to one of three classes of hunting opportunity: light at Ruiz and Jáuregui, moderate at Luján, and high at Ratti.

Hunting activity

We described the characteristics of hunting activity on the basis of interviews with hunters, local inhabitants, and wildlife managers in the cities (Luján and Mercedes) and rural settlements of our study area (Giarraca 1999, Peres 2001). Interviews (n = 43) were conducted to determine who hunts coypus in the area, as well as why, where and how they hunt.

We assessed hunting pressure in the four study sites as a combination of hunting opportunity (described above) and hunting activity. We estimated hunting activity by recording the presence of hunters, the number of burrows dug using a spade, and the number of cartridges at each site every 1–2 months throughout the study period. These criteria were based on the methods used to hunt coypus in our study area (see Results).

Population parameters and diet quality

Coypus were live-trapped in spring 1999 (October–November), summer 2000 (January–March), autumn 2000 (April–June), and winter 2000 (July–September) at the 4 study sites (methods described in Guichón *et al*. 2003b, c). Between 31 and 65 traps were used in the trapping sessions that lasted 4–11 days and were designed to capture most coypus present at each site, ending when recaptures exceeded 80% of total captures over 2 consecutive days. This trapping design resulted in the following effort (number of trap-nights) per site: 441–650 at Ruiz, 168–396 at Jáuregui, 124–170 at Luján, and 135–189 at Ratti. Cage traps (80 × 25 × 25 cm) were placed at burrow openings and on paths or foraging sites. Traps were baited with apple before sunset, and checked and closed before sunrise. Direct observations of coypus between sessions, which were conducted for a parallel study on social behaviour of coypu (Guichón *et al*. 2003b), indicated that almost all residents at the sites were marked under this regime.

Captured animals were marked and released at their trapping location. Coypus were immobilized for ~ 30 minutes by intra-muscular injection of ketamine hydrochloride ($4\ mg \cdot kg^{-1}$) combined with xylazine hydrochloride ($0.5\ mg \cdot kg^{-1}$) (Bó *et al.* 1994). New captures were marked for individual identification by two methods. Ear tags of different colours and shapes were complemented by a black hair dye applied to the dense under-fur on a 4×3-cm area of the head or back, after clipping guard hairs. Weight and sex were recorded for all individuals. Reproductive condition of females was assessed on the basis of whether or not the vulva was perforate, palpation of the abdomen, and the condition of teats (Gosling *et al*. 1981). A total of 87 individuals was identified at Ruiz, 55 at Jáuregui, 14 at Luján, and 10 at Ratti.

The minimum number alive (MNA) provided a good estimator of coypu abundance on the basis of a high and constant recapture probability predicted by Cormack-Jolly-Seber models at Ruiz and Jáuregui (Guichón *et al*. 2003c). We were unable to use these models at Luján and Ratti due to the low number of animals. However, direct observation of animals and sampling of signs of activity (collection of all faeces on the bank and recording of active burrows) conducted during and between trapping sessions indicated that coypu numbers were not underestimated by MNA (Guichón 2003). The MNA was calculated from the numbers of coypus trapped in a session plus any that avoided capture but were seen both during and after the session. Density at each site was estimated from the area covered by the water surface plus the surrounding 15 m of land, based on the restricted use of space by coypus in these sites (D'Adamo *et al*. 2000, Guichón 2003, Guichón *et al*. 2003b). Survival rate was estimated as the number of marked animals that were captured in one season divided by the total number of marked animals in the previous trapping session (Pollock *et al*. 1990); therefore, population losses (1 – survival) included emigration and mortality. Individuals first captured with a body weight < 1.5 kg were most likely offspring born on the site between trapping sessions, based on Brown (1975: juveniles weighed < 1.25 kg) and our recapture data (juveniles of 0.2–1.5 kg at first capture weighed 1.1–2.5 kg when recaptured while no new coypus of 1.5–2 kg were trapped); other first captures were assumed to be immigrants (Guichón *et al*. 2003c). Immigration rate was calculated as the number of immigrants divided by the total number of immigrants and residents in each season at each site. Rate of reproduction was estimated as the number of new offspring and pregnant females divided by the total number of individuals. We included the number of pregnant females so as to avoid underestimation of reproductive capacity due to harvesting of coypus, mainly adults, in habitats with heavy hunting pressure. These estimates showed the proportion of survivors, immigrants or recruits and pregnant females in each population so as to avoid underestimation of their relative importance in low density populations. Even if these may be rough estimates of the parameters compared to standard estimators obtained by C-M-R techniques, which were impeded by the limited amount of data, they provide appropriate measures for comparing among populations.

We determined the quality of coypu diet by using the percent nitrogen content of the faeces (Robbins 1983). Even if several factors may affect this index, this is a suitable and feasible estimate of diet quality for this species. At the beginning of each trapping session we collected all faeces deposited within the first two meters of the bank. Twenty-five faeces were selected at random from the pool of faeces collected each season at each site. Faeces were then dried at 60°C, ground, and analysed for nitrogen content using the Kjeldahl technique (AOAC 1980). Four samples were analysed each season and their average gave the percent nitrogen value for each season at each site.

Results

Hunting activity

Interviews conducted with local inhabitants revealed that hunting activity is a cultural tradition in the countryside with the coypu being a popular prey because of the meat and fur. In addition, young coypus are occasionally used as pets. Most (81%) of the people interviewed had participated in hunting. Costs of transport, accessibility and previous knowledge of the area constrained selection of hunting sites. Familiarity with the hunting site also rendered a more efficient harvest because hunters already knew the location of the burrows and foraging sites. Shooting, traping and burrow digging were the three methods used to harvest coypu, which occurred throughout the year regardless of the closed season (October–April).

Differences in hunting activity among sites were estimated throughout the study period. The number of hunting signs at each site was significantly different than expected by chance (Ruiz = 0, Jáuregui = 1, Luján = 5, Ratti = 34; $\chi^2 = 78.2$, $p < 0.001$). Combining these data with hunting opportunity at each site, described in the preliminary campaigns, hunting pressure was classified as null or light at Ruiz and Jáuregui, moderate at Luján, and heavy at Ratti.

Population parameters and diet quality

Density of coypus differed among sites ($F_{3,12}$ = 42.37, p < 0.001), with the largest value at Ruiz and the lowest at Ratti (Fig. 1). Population losses ($F_{3,8}$ = 5.35, p = 0.026) and the proportion of immigrants ($F_{3,8}$ = 8.95, p = 0.006) were also significantly different among sites, being smaller at the two sites with almost no hunting pressure (Fig. 1). Therefore, the site with heavy hunting pressure had low density and a high turnover rate. Reproduction occurred in all sites (Fig. 1; $F_{3,12}$ = 0.79, p = 0.5).

We analysed diet quality to evaluate whether nutritional deficiencies were related to the low numbers found at the site with heavy hunting pressure. Diet quality differed among sites ($F_{3,12}$ = 4.47, p = 0.025) but was highest at Ratti (Fig. 1).

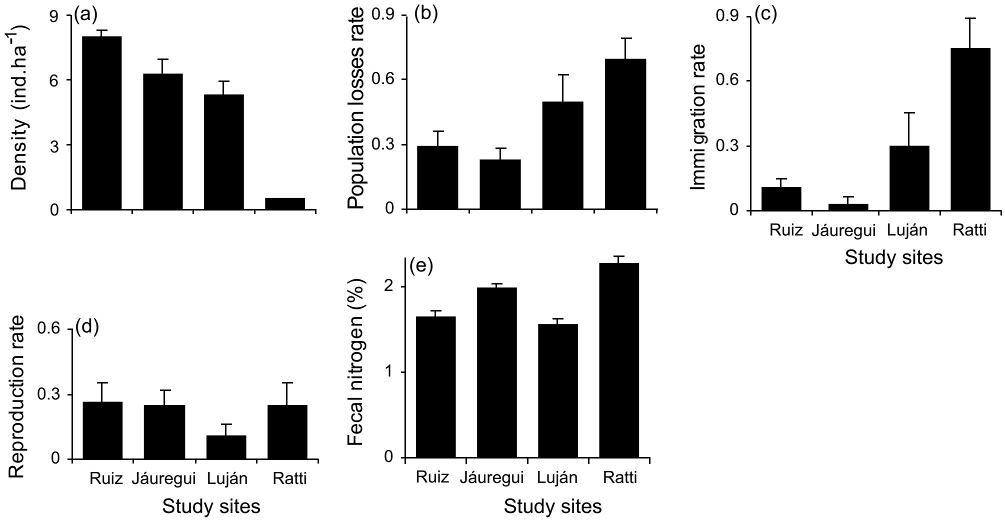

Fig. 1. Mean values (± SE) of: (a) coypu density (n = 4), (b) population losses rate estimated as the proportion of individuals that emigrated and died (n = 3), (c) immigration rate estimated as the proportion of newcomers (n = 3), (d) reproduction rate estimated as the proportion of newborns and pregnant females (n = 4), and (e) fecal nitrogen content (n = 4) estimated throughout the year at each study site. Hunting pressure was light at Ruiz and Jáuregui, moderate at Luján, and heavy at Ratti.

Discussion

The two sites with heavy and moderate intensity of hunting pressure showed relatively low coypu density and high immigration and population losses. No deficiencies in either reproduction or diet quality were evident at these sites, suggesting that they were suitable for colonization and breeding. However, the effective number of births and juveniles reaching reproductive age was limited by hunting. The persistence of these populations was probably due to dispersing individuals. Our results indicate that hunting pressure may modify the structure of coypu populations that otherwise inhabit a relatively stable environment (Guichón *et al.* 2003c).

In the pampas region, one of the main features determining landscape heterogeneity for coypus is the spatial variation in hunting pressure. Our interviews indicated that this variation in coypus' hunting pressure is determined by accessibility of hunting sites, distance to urban or rural settlements, human population density, and effective control of hunting in each field. This shows how the spatial structure of the environment influences the decisions made by hunters, as was reported in other studies (eg Hofer *et al*. 1996: distance to settlements and presence of roads, Brøseth and Pedersen 2000: starting point of hunters, Millner-Gulland 2001: costs involved in travelling to hunting sites).

Coypus have relatively small home ranges but good dispersal and colonising abilities (Kinler *et al*. 1987, Gosling and Baker 1989, Doncaster and Micol 1990, Carter and Leonard 2002). The presence of areas with different hunting pressure may produce a flux of dispersing individuals from protected (high density) areas to hunted (low density) areas, as suggested by the higher proportion of immigrants in the sites with higher hunting pressure. This scenario indicates that coypu population dynamics in the pampas agro-systems could be analysed using source-sink models. Source-sink dynamics were previously suggested to describe coypu population behaviour in Europe where either poisoning or shooting generated sink habitats for individuals excluded from surrounding high density populations (Gosling 1988, Gosling *et al*. 1988, Doncaster and Micol 1989, Reggiani *et al*. 1993). If this type of population dynamics is corroborated in further studies, it will be a useful approach to obtain more realistic models of hunting systems (Tuck and Possingham 1994, McCullough 1996, Ritchie 1997, Lundberg and Jonzén 1999, Milner-Gulland 2001).

We propose that the spatial structure of both coypu populations and environmental heterogeneity should be taken into account for managing coypu harvest. This approach is strongly linked with the spatial scale involved in management decisions, which must consider a spatial scale sufficiently large to incorporate hunting areas close to potential sources of dispersing individuals (Novaro *et al*. 2000). We acknowledge the limitations of this study, mainly related to the short study period and low number of sites. However, this is the first systematic study analysing the effect of hunting on populations of coypu in their native habitat, providing valuable information for their control or commercial exploitation.

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