Mammalian Biology 80 (2015) 260–264

Contents lists available at ScienceDirect

Mammalian Biology

journal homepage: www.elsevier.com/locate/mambio

Short Communication

Dissimilar responses of the Gray brocket deer (*Mazama gouazoubira*), Crab-eating fox (*Cerdocyon thous*) and Pampas fox (*Lycalopex gymnocercus*) to livestock frequency in subtropical forests of NW Argentina

Ana Sofía Nanni *

Instituto de Ecología Regional, Universidad Nacional de Tucumán & Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), cc. 34, Yerba Buena, Tucumán, Argentina

ARTICLE INFO

Article history:
Received 30 December 2014
Accepted 22 April 2015
Handled by Francesco Ferretti
Available online 29 April 2015

Keywords:
Extensive ranching
Gray brocket deer
Crab-eating fox
Pampas fox
Subtropical forests

ABSTRACT

This study represents the first analysis of livestock influence over individual mammal species in NW Argentina forests. Through camera-trapping, I found a negative correlation between frequencies of occurrence of livestock (sheep, goats and cattle) and Gray brocket deer *Mazama gouazoubira*, and a modification of the daily activities patterns of the latter according to changes in density of the former. However, no evident associations between Crab-eating fox *Cerdocyon thous* and Pampas fox *Lycalopex gymnocercus* frequencies and livestock were found. This study provides insights on the effects of extensive ranching over mammal species in NW forests of Argentina, where this activity is of major importance among forests inhabitants.

Human land use has a major influence on biodiversity. Most studies assessing the effect of land use on vertebrates focus on processes of land cover change such as deforestation or agriculture expansion. However, in many areas, the prevalent land use is extensive livestock ranching, which occurs without drastic change in land cover. Extensive ranching is widespread in the terrestrial landscape, especially in areas where alternative forms of production are limited by climate and terrain (Niamir-Fuller et al., 2012), and it is often characterized by low human and livestock population densities, and low level of inputs compared to other agricultural production systems (Thornton et al., 2002). These features have usually allowed higher density and diversity of wildlife compared to other major land uses such as cropping and urbanization, but there has been considerable debate regarding the impact of livestock grazing on native species (Fleischner, 1994; Grootenhuis and Prins, 2000). In South America, extensive ranching in forests is a major activity among rural communities, especially in dry (Grau et al., 2008) and Andean forests (Hecht, 1993); however, the direct impact of livestock over target groups, such as large mammals, has not been assessed.

Competition over space and shared resources is probably the key process governing the impact of livestock on large mammals, but it has been suggested to be largely asymmetrical and to vary widely among species (Prins, 2000). While wild herbivores exhibit the most direct effects, due to dietary niche overlap (Voeten and Prins, 1999), in the case of other functional groups, such as carnivores, livestock grazing influence is rather more indirect, for example through its impact on vegetation and soil, thus affecting prey and habitat cover availability (Eccard et al., 2000; Stanley and Knopf, 2002). Also, conflicts with livestock ranchers over depredation of small and large livestock are one of the major causes of decline of wild carnivores (Michalski et al., 2006).

In NW Argentina, strong gradients of temperature and rainfall determine the co-existence of different types of forests (dry in lowlands and moister as altitude increases, Fig. 1) and land-uses, from intensive agriculture and cattle ranching in lowlands to more traditional practices such as shifting agriculture and extensive ranching at higher altitudes, where most rural population inhabits (Izquierdo and Grau, 2009). This sharp elevation gradient also conditions native mammal assemblages composition (Di Bitetti et al., 2013), deriving in high gamma diversity for some mammal groups (Jayat

* Tel.: +54 381 4255174.
E-mail address: sofiananni@gmail.com

http://dx.doi.org/10.1016/j.mambio.2015.04.003
1616-5047/

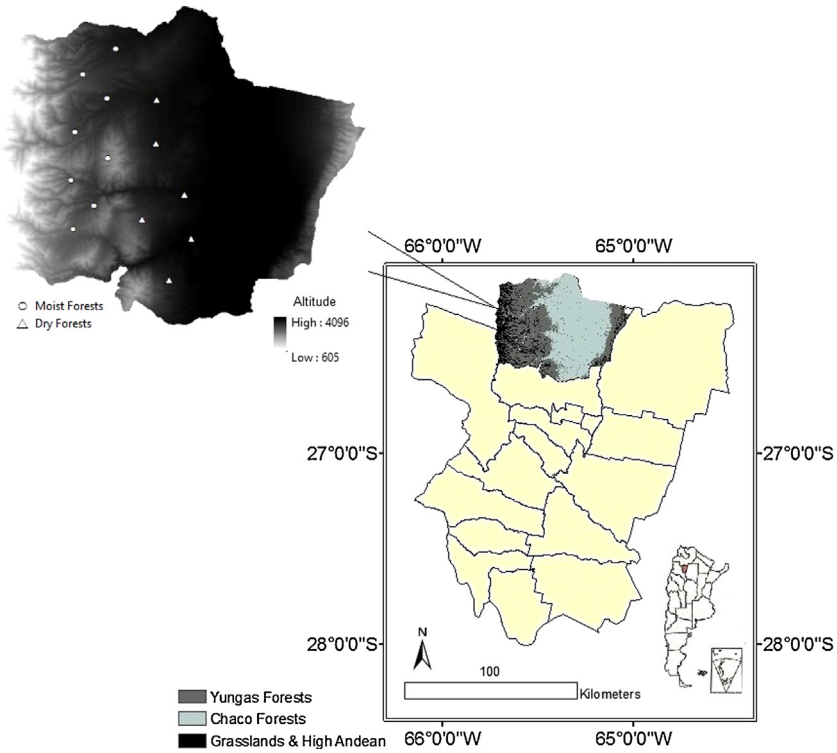

Fig. 1. Relative location of the study area within the province limits, including altitudinal gradient, main ecoregions and location of the study sites.

and Ortiz, 2010). Among all medium and large mammal species in the region, the Gray brocket deer (*Mazama gouazoubira*) is the most frequent wild herbivore registered, while the Crab-eating fox (*Cerdocyon thous*) and the Pampas fox (*Lycalopex gymnocercus)* are two relatively abundant carnivores (Di Bitetti et al., 2013; Jayat and Ortiz, 2010). The Gray brocket deer is a small, mainly diurnal cervid, showing a wide distribution to the east of the Andes in South America, from Venezuela to the northern half of Argentina (Emmons, 1990; Maffei et al., 2002). The Crab-eating fox and Pampas fox are two widespread and relatively common South America foxes, and in Argentina they are distributed in the northern and north-central portion of the country, respectively, with the exception of the High Andes and the Atlantic forest in Misiones province in the case of the Pampas fox (Jácomo et al., 2004; Vieira and Port, 2007). These two species have generally been described as habitat generalists, using both dry and moist forests, forest edges and savannas to different degrees, but the Crab-eating fox shows a preference for structurally more complex forests, whereas Pampas fox is more frequent in open habitats (Langguth, 1975). Also, Crab-eating fox exhibits rather crepuscular or nocturnal habits while the Pampas fox can be active both day and night (Brady, 1979; Brooks, 1992).

Here, I describe the association between camera-traps records of these three species and cattle in a subtropical watershed in NW Argentina, in order to assess for relationships between the two foxes and deer and livestock frequency and whether segregation of daily activity patterns was found in species which negatively related with livestock presence.

Camera-trap surveys were set between July 2013 and December 2014 to record medium to large mammals in 14 sites within the study area, a department in north Tucumán that covers most part of the Tapia-Trancas subtropical watershed (Fig. 1). Six sites were allocated in drier, low elevation forests and eight in moister, montane forests, covering an altitude range from 700 to 1500 m.a.s.l. The study area exhibits a steep topographic gradient, which results in wide ranges of temperature and rainfall; from 300 to 600 mm/year and 18 °C in the lowlands to 600–800 mm/year of annual rainfall in the mid-elevation mountain slopes. Dry Chaco forests in lowlands are dominated by the White quebracho *Aspidosperma quebracho-blanco*, the Guayacán *Caesalpinia paraguanensis* and *Acacia spp.* As altitude increases, humid forests dominate, with species such as Nogal criollo *Juglans australis*, Horco cebil *Parapiptadenia excelsa*, Cocucho *Zanthoxylum coco* and Viraró *Ruprechtia laxiflora*. Mammal assemblages in dry and moist forests share a number of species (e.g. Geoffroy's cat *Oncifelis geoffroyi*, Collared pecari *Tajasu pecari*, Cougar *Puma concolor*, Nine-banded armadillo *Dasypus novemcinctus*), but some species are exclusively found in dry forests (e.g., little hairy armadillo *Chaetophractus vellerosus*, Southern three-banded armadillo *Tolypeutes matacus*) while others are more restricted to moist forests (e.g. Crab-eating raccoon *Procyon cancrivorus*). Extensive cattle ranching occurs both in dry and moist forests and the most common species are goats, sheep and cattle (*pers. obs).* Sites were at least 2 km apart from each other to ensure independence of species records. Stations consisted of one Moultrie M-880 camera-trap deployed >100 m from the nearest unpaved road, placed 50 cm above ground and attached to a tree trunk, set to be active 24 h a day and with a delay of 4 min between successive photographs.

Total sampling effort was 620 days. On average, camera-trap stations were active for 41.33 ± 10.0 days (mean ± SD), but due to a low number of trap-cameras, each one was replaced every 10–20 days and relocated elsewhere, obtaining a set of 2–5 subsamples per site (57 subsamples in total). The two fox species were easily differentiated in the photographic records by their physical appearance, size and coloration. In all cases, >12 h had to pass between successive livestock or wild mammals pictures to be considered independent records, using the criterion in Di Bitetti et al. (2013), unless they were easily distinguished at the individual level by certain features (typically antlers in the case of Gray brocket deer, or coloration in livestock). Wild mammals and livestock records were transformed to a daily rate (frequency) by dividing the number of records by

the number of days the station was active in each location (i.e., frequency = *N* records/days/location). Since livestock and wild species frequencies varied widely among subsamples, I treated each subsample as independent for the purposes of this study. Relationships between livestock and wild species were statistically assessed by means of Spearman non-parametric correlations, using the frequency of wild species records in each of the 57 subsamples as the dependent variable and that of livestock as the independent variable. I also aimed at testing the hypothesis that gray brocket daily activity patterns varied with livestock frequency. In order to do this, I classified single gray brocket records in four 6 h-intervals corresponding to 00–06 am (1), 06–12 pm (2), 12–18 pm (3) and 18–00 am (4); and livestock frequency in null, low (<0.5) and high (>0.5) and performed independence (likelihood ratio) tests in contingency tables to analyze whether there were significant differences in livestock frequencies among these time categories. I used tests of independence to explore if daily activity patterns were different among the two foxes species as well, using the four 6 h-intervals described above. The temporal distribution of these records was summarized in line-graphs representing the day divided in twelve 2-h periods (Fig. 2b). All analyses were performed using R Studio software.

I obtained 61 records of Pampas fox, 22 of Crab-eating fox and 59 records of Gray brocket deer in 620 camera-trap days, while livestock (cows, goats, sheep and horses) summed 242 records. Pampas fox was recorded in 13 sites and 36% of all subsamples while the Crab-eating fox was found in only 7 sites and 22% of subsamples. The Gray brocket deer was the most widespread of the 3 species, occurring in 13 sites and 55% of subsamples. Gray brocket deer frequency was negatively and significantly correlated with livestock frequency (rho = −0.48, $p < 0.001$), with virtually no records at livestock frequencies >1, (Fig. 2a); while Crab-eating fox frequency showed a negative although not significant association (rho = −0.20, $p = 0.12$, Fig. 2b). Pampas fox frequency, in contrast, was not correlated at all with livestock frequency (rho = −0.04, $p = 0.75$, Fig. 2c). The probability of recording the Gray Brocket at a specific time interval was not independent of livestock frequency (likelihood ratio test, $Chi^2 = 11.77$, $p = 0.002$): in the absence of domestic animals, records were evenly distributed, but at high and low livestock frequencies, early morning and afternoon records tended to decrease, and most records occurred at night. The two foxes species daily activity patterns also significantly differed ($Chi^2 = 19.51$, $p < 0.001$), and were rather complementary (Fig. 3b). Records of the Crab-eating fox were mainly nocturnal, with a sharp peak between 20 and 22 pm, while Pampas foxes were active during all day, but exhibited two peaks at dawn and dusk (Fig. 3b). These results suggest that, in the study area, Gray brocket deer is segregating both spatially and temporally from livestock. Spatial segregation may be a strategy to minimize competition for resources, while temporal segregation might be the result of avoidance behavior (Rivero et al., 2004). While no effect of foraging domestic animals activity was observed in the frequency of the two fox species, the Crab-eating fox frequency tended to decrease with high frequencies of livestock. Still, their daily activity patterns corresponded to the common behavior of both species, and were similar to those found for these two foxes in other regions of Argentina (Di Bitetti et al., 2009).

My findings agree with other studies assessing competition among domestic animals and wildlife (e.g., Madhusudan, 2004; Young et al., 2005), in which large herbivores abundance was negatively affected, due to dietary overlap. However, these studies have mostly been carried out in African rangelands, with little to no insight in subtropical forests. Nevertheless, livestock has been shown to highly modify forests, by reduction of vegetation cover, plant species composition and soil disturbance and erosion (Fleischner, 1994); but whether this derives in direct, indirect or

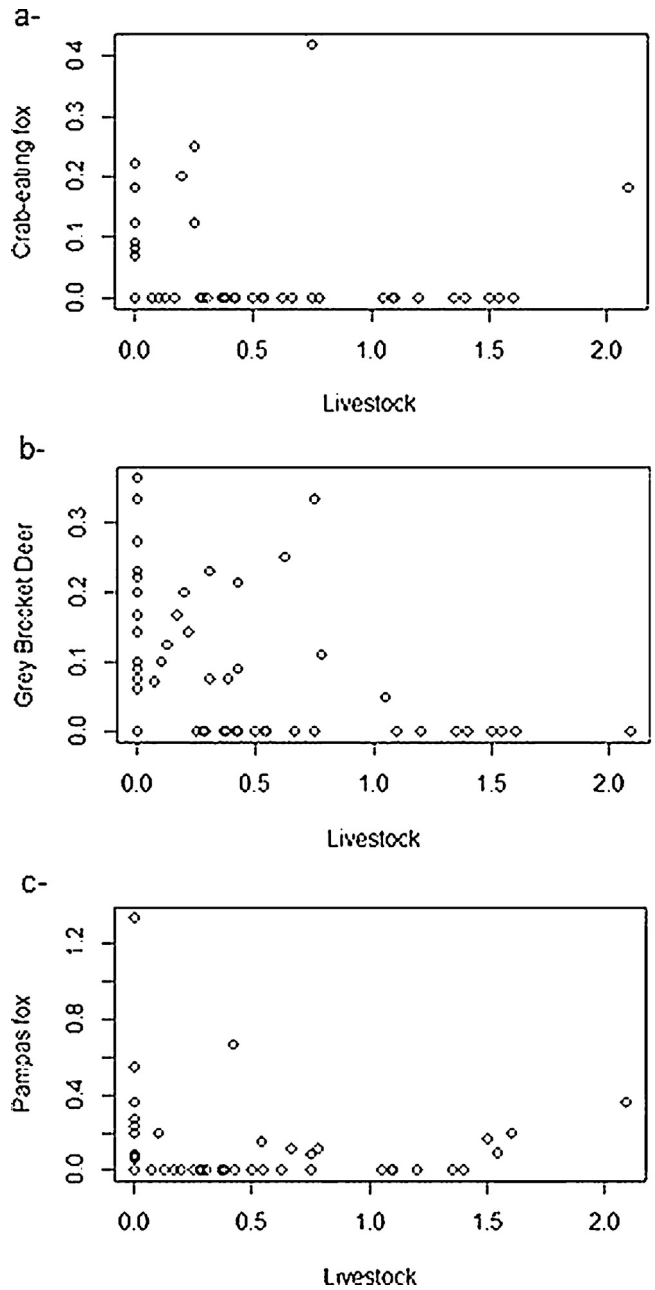

Fig. 2. Scatterplots of livestock frequency and (a) Crab-eating fox, (b) Gray brocket deer and (c) Pampas fox frequencies in each subsample.

null effects over mammal assemblages will vary among species and functional groups. For example, large carnivores usually suffer the retaliation of cattle owners, because of predation on their livestock (Loveridge et al., 2010), and are important game species; therefore, distance to areas frequented by poachers rather than livestock abundance may be a better proxy of their presence (Caro, 1999). Medium-sized carnivores or omnivore species such as the Crab-eating fox and the Pampas fox, on the other hand, may not suffer direct exclusion by domestic animals, but their feeding ecology can be altered by livestock abundance, due to changes in prey availability, as it has been the case of culpeo foxes (*Pseudalopex culpaeus)* in central Argentina (Sarsfield, 2003). These contrasts in mammal responses might explain the lack of associations found between native mammal assemblages and domestic animals in subtropical montane forests of Salta, Argentina (Di Bitetti et al.,

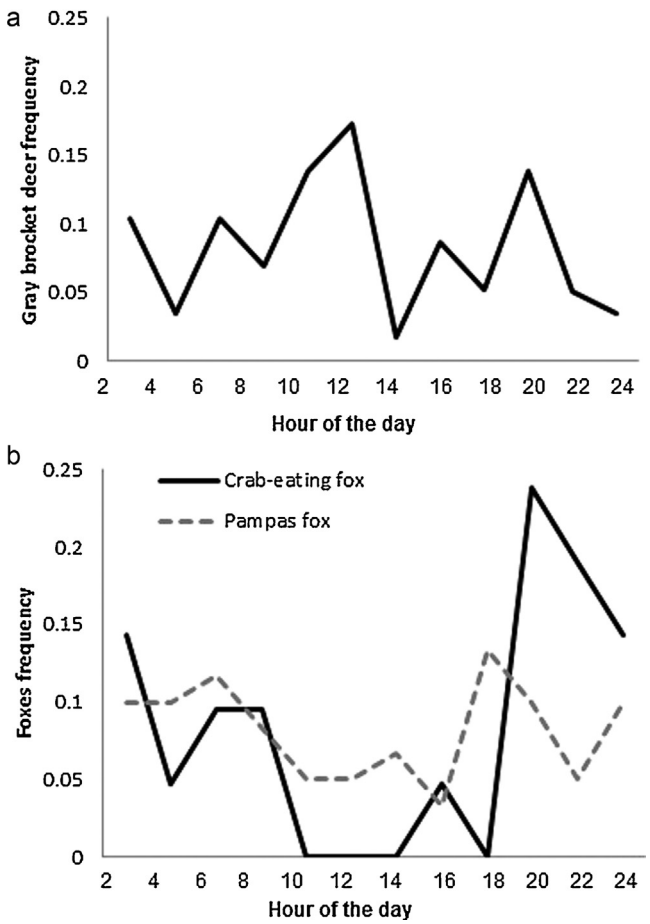

Fig. 3. Daily camera trap frequencies of (a) Gray brocket deer and (b) Crab-eating fox (black line) and Pampas fox (dotted line).

2013), enhancing the need of assessing for individual species responses.

Although Gray brocket deer is considered to be Least Concern due to its relatively large distribution (IUCN, 2001) it is also one important game species (Bodmer, 1995) and it has been hypothesized that in Argentina their populations are declining due to hunting pressure and habitat loss (Dellafiore and Maceira, 1998; Juliá and Richard, 1990). The negative association between these species and the frequency of livestock, and the temporal segregation of its daily activity at different livestock intensities may also reflect the indirect influence of human presence, since livestock is likely more frequent around rural densely populated areas. However, the study area has experimented reductions in extensive livestock between 1988 and 2002, partially due to rural out-migration between 1991 and 2001 (Nanni and Grau, 2014), which can ultimately turn into opportunities of recovery for the Gray brocket deer, and other species populations threatened by extensive livestock foraging in forests, and its side effects. This study constitutes the first assessment of extensive livestock frequency over individual mammal species, and it provides insights for three of the most widespread mammals in NW Argentina forests.

Acknowledgements

I want to thank Mariana Araoz, Lucía Barquez, Sofía d'Hiriart and all the field assistants who helped during camera-trap setting. Neotropical Grassland Conservancy provided two camera-traps and the research was funded by Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), and Rufford Small Grants for my PhD project "Land use change and ecosystem services provision in a subtropical watershed".

References

Brady, C.A., 1979. Observations on the behavior and the ecology of the Crab-eating fox (*Cerdocyon thous*). In: Eisenberg, J.F. (Ed.), Vertebrate Ecology in the Northern Tropics. Smithsonian Institution Press, Washington, DC, pp. 161–171.
Bodmer, R.E., 1995. Managing Amazonian wildlife: biological correlates of game choice by detribalized hunters. Ecol. Appl., 872–877.
Brooks, D.M., 1992. Notes on group size, density and habitat associations of the Pampas fox (*Dusicyon gymnocercus*) in the Paraguayan Chaco. Mammalia 56, 314–316.
Caro, T.M., 1999. Densities of mammals in partially protected areas: the Katavi ecosystem of western Tanzania. J. Appl. Ecol. 36 (2), 205–217.
Dellafiore, C., Maceira, M., 1998. Problemas de conservación de los ciervos autóctonos de la Argentina. Mastozool. Neotrop. 5, 137–165.
Di Bitetti, M.S., Di Blanco, Y.E., Pereira, J.A., Paviolo, A., Pérez, I.J., 2009. Time partitioning favors the coexistence of sympatric Crab-eating foxes (*Cerdocyon thous*) and Pampas foxes (*Lycalopex gymnocercus*). J. Mammal. 90 (2), 479–490.
Di Bitetti, M.S., Albanesi, S.A., Foguet, M.J., De Angelo, C., Brown, A.D., 2013. The effect of anthropic pressures and elevation on the large and medium-sized terrestrial mammals of the subtropical mountain forests (Yungas) of NW Argentina. Mammal. Biol.-Z. für Säugetierkd. 78 (1), 21–27.
Eccard, G.A., Walter, R.B., Milton, S.J., 2000. How livestock grazing affects vegetation structure and small mammal distribution in the Semi-Arid Karoo. J. Arid Environ. 46, 103–106.
Emmons, L., 1990. Neotropical Rainforests Mammals. A field Guide. The University of Chicago Press, Chicago.
Fleischner, T.L., 1994. Ecological costs of livestock grazing in western North America. Conserv. Biol. 8 (3), 629–644 (rangelands. *Conservation Biology*, 1644–1647).
Grau, H.R., Gasparri, N.I., Aide, T.M., 2008. Balancing food production and nature conservation in the Neotropical dry forests of northern Argentina. Global Change Biol. 14 (5), 985–997.
Grootenhuis, J.G., Prins, H.H., 2000. Wildlife utilisation: a justified option for sustainable land use in African savannas. In: Wildlife Conservation by Sustainable Use. Springer, Netherlands, pp. 469–482.
Hecht, S.B., 1993. The logic of livestock and deforestation in Amazonia. Bioscience 43, 687–695.
IUCN, S.S.C., 2001. IUCN Red List categories and criteria: version 3.1. IUCN Species Survival Commission.
Izquierdo, A.E., Grau, H.R., 2009. Agriculture adjustment, land-use transition and protected areas in Northwestern Argentina. J. Environ. Manage. 90 (2), 858–865.
de Almeida Jácomo, A.T., Silveira, L., Diniz-Filho, J.A.F., 2004. Niche separation between the maned wolf (*Chrysocyon brachyurus*), the Crab-eating fox (*Dusicyon thous*) and the hoary fox (*Dusicyon vetulus*) in central Brazil. J. Zool. 262 (01), 99–106.
Jayat, J.P., Ortiz, P.E., 2010. Mamíferos del pedemonte de Yungas de la Alta Cuenca del Río Bermejo en Argentina: una línea de base de diversidad. Mastoozol. Neotrop. 17, 69–86.
Juliá, P., Richard, E., 1990. Uso de habitat para forrajeo por parte de la corzuela parda (*Mazama gouazoubira*) en ambientes secundarios de las Yungas y en condiciones controladas. Acta Zool. Lilloana 45, 247–256.
Langguth, A., 1975. Ecology and evolution in South American canids. In: Fox, M.W. (Ed.), The Wild Canids. Van Nostrand Reinhold Co, New York, pp. 192–206.
Loveridge, A.J., Wang, S.W., Frank, L.G., Seidensticker, J., 2010. People and wild felids: conservation of cats and management of conflicts. Biol. Conserv. Wild Felids, 161.
Madhusudan, M.D., 2004. Recovery of wild large herbivores following livestock decline in a tropical Indian wildlife reserve. J. Appl. Ecol. 41 (5), 858–869.
Maffei, L., Cuellar, E., Noss, A., 2002. Uso de trampas cámara para la evaluación de mamíferos en el ecotono Chaco-Chiquitanía. Rev. Boliv. Ecol. Conserv. Ambient 11, 55–65.
Michalski, F., Boulhosa, R.L.P., Faria, A., Peres, C.A., 2006. Human–wildlife conflicts in a fragmented Amazonian forest landscape: determinants of large felid depredation on livestock. Anim. Conserv. 9 (2), 179–188.
Nanni, A.S., Grau, H.R., 2014. Agricultural adjustment, population dynamics and forests redistribution in a subtropical watershed of NW Argentina. Reg. Environ. Change (in press).
Niamir-Fuller, M., Kerven, C., Reid, R., Milner-Gulland, E., 2012. Co-existence of wildlife and pastoralism on extensive rangelands: competition or compatibility? Pastoralism 2 (1), 1–14.
Prins, H.H., 2000. Competition between wildlife and livestock in Africa. In: Wildlife Conservation by Sustainable Use. Springer, Netherlands, pp. 51–80.
Rivero, K., Rumiz, D.I., Taber, A.B., 2004. Estimating brocket deer (*Mazama gouazoubira* and *M. americana*) abundance by dung pellet counts and other indices in seasonal Chiquitano forest habitats of Santa Cruz, Bolivia. Eur. J. Wildlife Res. 50 (4), 161–167.
Sarsfield, A.V., 2003. Effects of livestock on the feeding ecology of endemic culpeo foxes (*Pseudalopex culpaeus* smithersi) in central Argentina. Revista Chilena de Historia Natural 76, 313–321.
Stanley, T.R., Knopf, F.L., 2002. Avian responses to late-season grazing in a shrub-willow floodplain. Conserv. Biol. 16 (1), 225–231.

Thornton, P.K., Kruska, R.L., Henninger, N., Kristjanson, P.M., Reid, R.S., Atieno, F., Odero, A., Ndegwa, T., 2002. Mapping Poverty and Livestock in the Developing World. International Livestock Research Institute, Nairobi.

Vieira, E.M., Port, D., 2007. Niche overlap and resource partitioning between two sympatric fox species in southern Brazil. J. Zool. 272 (1), 57–63.

Voeten, M.M., Prins, H.H., 1999. Resource partitioning between sympatric wild and domestic herbivores in the Tarangire region of Tanzania. Oecologia 120 (2), 287–294.

Young, T.P., Palmer, T.M., Gadd, M.E., 2005. Competition and compensation among cattle, zebras, and elephants in a semi-arid savanna in Laikipia, Kenya. Biol. Conserv. 122 (2), 351–359.