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Short communication

A native top predator relies on exotic prey inside a protected area: The puma and the introduced ungulates in Central Argentina

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A B S T R A C T

Top predators play an important role to preserving healthy and functional ecosystems. Predatory interactions among generalist predators and native prey may be altered due to occurrence and availability of introduced prey species. These interactions seldom receive attention in biodiversity conservation, particularly when establishing protected area management guidelines. In this study we described puma (*Puma concolor*) diet in a protected area from central Argentina, where red deer (*Cervus elaphus*) and wild boar (*Sus scrofa*) were regionally introduced for game a hundred years ago. We aimed to evaluate if the puma effectively bases its diet on native prey species maintaining natural ecological interactions despite the occurrence and availability of these introduced prey species. We analyzed 83 puma scats in a landscape containing both native and introduced species susceptible to predation. Results indicate that puma diet was composed mostly by introduced species, which represented 80.8% of the total biomass consumed (*Cervus elaphus* 40.6%, *Sus scrofa* 39.4%, and *Ovis aries* 0.8%). Pumas mainly preyed on introduced ungulates in the protected area, where management guidelines do not account for puma-native prey interactions. We suggest implementation of management actions to reduce densities of these introduced ungulates to restore natural ecological interactions between the puma and native prey.

1. Introduction

Ecological theory predicts that top predators promote species richness and are spatio-temporally associated with it for different causative or non-causative reasons such as: resource facilitations, trophic cascades, dependence on ecosystem productivity, sensitivity to dysfunctions, selection of heterogeneous sites and links to multiple ecosystem components (Sergio et al., 2008). Thus top predators play an important role to preserve ecological functions and dynamics of ecosystems (Estes et al., 2011). However, many of these ecological functions depend on the maintenance of mutual interactions between predators and their prey. Traditionally management of protected areas used to direct efforts to a single species, disregarding mutual interactions between predators and their prey, which have been recognized as an important component of biodiversity conservation (Sinclair and Byrom, 2006).

Top predators could also be key species on ecosystem functioning. Among large mammalian carnivores, for example, functional (i.e. shifts in predator food habits) or numerical (i.e. shifts in predator abundance) responses, sometimes exerted by just few individuals, can initiate and sustain strong predation-driven effects on communities and ecosystems. These effects generate impacts that transcend through trophic levels, known as "top-down" effects (Menge, 1992). For example, a change in the diet of a top predator

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-caused by a marked reduction or increase in the availability of its native or even an introduced prey-can cause constant top-down influence throughout prey population cycles (Miller et al., 2001).

The puma (*Puma concolor*) is a top predator with strong top-down influences (Ripple and Beschta, 2006; Sarasola et al., 2016). This large cat is a well known generalist and opportunistic predator throughout the Americas (Sunquist and Sunquist, 2002). Their diet is frequently affected by prey availability (i.e., abundance and vulnerability), fluctuations in native prey populations, competition with other carnivores, habitat characteristics, changes in landscape use, and anthropogenic factors such as legal and illegal hunting of prey (Foster et al., 2010; Novaro et al., 2000). For instance, a study conducted in Quebrada del Condorito National Park in central Argentina showed that pumas mainly preyed on introduced wild species and livestock, yet pumas shifted their prey selection toward native species when livestock was removed from the area (Pia, 2013). Due to these generalist and opportunistic behaviors, puma-prey interactions may be rapidly and severely affected by management guidelines established in private and protected areas.

Red deer (*Cervus elaphus*) and wild boar (*Sus scrofa*) were first introduced to Argentina, in a private game reserve, for sport hunting in 1907 (Amieva, 1993). In 1968, this game reserve was established as a protected area, Parque Luro Natural Reserve (PLNR). However, these introduced ungulate species were not removed at the time of protected status establishment. In this study, we aimed to assess whether the puma effectively bases its diet mainly on native prey species despite the abundance and availability of introduced ungulates in the PLNR.

2. Materials and methods

2.1. Study area

This study was conducted in the PLNR located in La Pampa province, Argentina. The PLNR is a 76-km^2 protected area, representing the best preserved remnant of Caldén forest (*Prosopis caldenia*), encompassed in the Espinal phytogeographic province (Cabrera, 1976) in central Argentina (Fig. 1). The vegetation structure is characterized by tree coverage ranging from 30 to 50%, grasslands in the herbaceous stratum and low bush cover. Topography is characterized by slumps and lagoons. The weather is characterized by subhumid-dry conditions; average temperatures in summer and winter are 23 °C and 8 °C, respectively. The region receives a mean annual precipitation of 550 mm.

2.2. Prey remain analysis

During summer (January) and winter (July–August) 2003, and winter (July–August) 2004, we collected puma scats along 120 km of internal and peripheral dirt roads, within the PLNR. We identified puma scats based on physical appearance: size, color, and shape. We were certain about scats identification as belonging to pumas because there are no other species in the area that may produce scats of similar appearance. We stored scats in labeled paper envelopes. Thereafter, in the laboratory, we identified and quantified prey item remains present in scat samples. We identified prey remains using our own reference collections and keys for mammals and birds (Chehébar and Martín, 1989; Pearson, 1995). Whenever possible, we identified prey items to the species level, and grouped by taxon. Puma diet is expressed as percent occurrence (number of times a prey item occurred as percentage of the total number of prey items in all scats) and relative biomass of prey consumed. We calculated the relative biomass and numbers of prey consumed by puma using the equation proposed by Ackerman et al. (1984); this method corrects for underrepresentation of large-sized prey. We obtained prey body masses from literature (Redford and Einseberg, 1992) and from our own records collected at the study area.

3. Results

We conducted prey remain analysis in 83 scats. Pumas consumed at least 18 taxa in the PLNR, which included 15 wild mammal and three bird species (Table 1). We were able to identify14 mammals to the species level. We created a feline category (*Leopardus* sp.) to combine two possible small cat species (*Leopardus geoffroyi* and *L. colocolo*), present at the PLNR, that are impossible to differentiate through bone and hair remains. We identified three bird taxa, the eared dove (*Zenaida auriculata*), and two taxa with undetermined species (Anatidae and unidentified bird).

Puma diet was composed mostly by introduced species: red deer, wild boar, sheep (*Ovis aries*), and european hare (*Lepus europaeus*) (Table 1). Introduced ungulates represented 80.8% of total biomass consumed by pumas, with red deer and wild boar contributing the highest biomass (Table 1). Puma also consumed domestic sheep, which was undoubtedly obtained beyond the boundaries of the PLNR (Table 1). In smaller proportion, pumas consumed native prey, such as the geoffroy's cat, Molina's hog-nosed skunk (*Conepatus chinga*), armadillos (*Chaetophractus villosus* and *Zaedyus pichiy*), birds, and small rodents (Table 1).

The group of bird prey occurred most frequently with a total of 40.6% (eared dove 21.3% and unknown birds 18.8%) followed by introduced ungulates (30.6%) (Table 1).

4. Discussion

Pumas consumed more non-native than native prey at the PLNR. The main prey items in puma diet were introduced ungulate species, red deer and wild boar. None of the native prey species identified in puma diet at the PLNR reached similar occurrence rates or biomass to those of the large introduced ungulates. Yet, the puma feed mainly on native ungulates almost everywhere throughout their range (Iriarte et al., 1990). Moreover, the puma has been recognized as a generalist and opportunistic predator (Sunquist and Sunquist, 2002), basing its diet on small and medium native species, as armadillos in Mexican montane forests (Gómez-Ortiz and Monroy-Vilchis, 2013), medium rodents in central (Foster et al., 2010) and south America (Branch et al., 1996), and small rodents in the high mountains of central Argentina (Pia, 2013).

By a way of proof of its recognized generalist and opportunistic behavior, pumas could heavily prey, regardless of size, on the most abundant and available species at a given area, such as plains vizcachas (*Lagostomus maximus*) in the Monte desert in central Argentina (Branch et al., 1996), penguins in southern Patagonia coast (Zanón Martínez et al., 2012), doves in the semiarid forest of the Espinal biome (Sarasola et al., 2016) or wild ungulates like guanacos (*Lama guanicoe*) and vicuñas (*Vicugna vicugna*) in northwestern Argentina (Donadio et al., 2009). We do not have prey abundances to evaluate prey selection by the puma in our study. Therefore, we provide assertive evidence of puma dietary shift to introduced ungulates, something probably accountable to the exceptionally high abundance of these introduced ungulate species. Red deer density was estimated in 28.9 individuals/100 ha (Zanón Martínez, unpublished data) at PLNR, one of the highest recorded for the species through its distribution range (Wilson and Mittermeier, 2011). Such exceptionally high abundance could be due to the confinement of red deer population provided by a 2 m high perimeter fence around the reserve. There are no wild boar

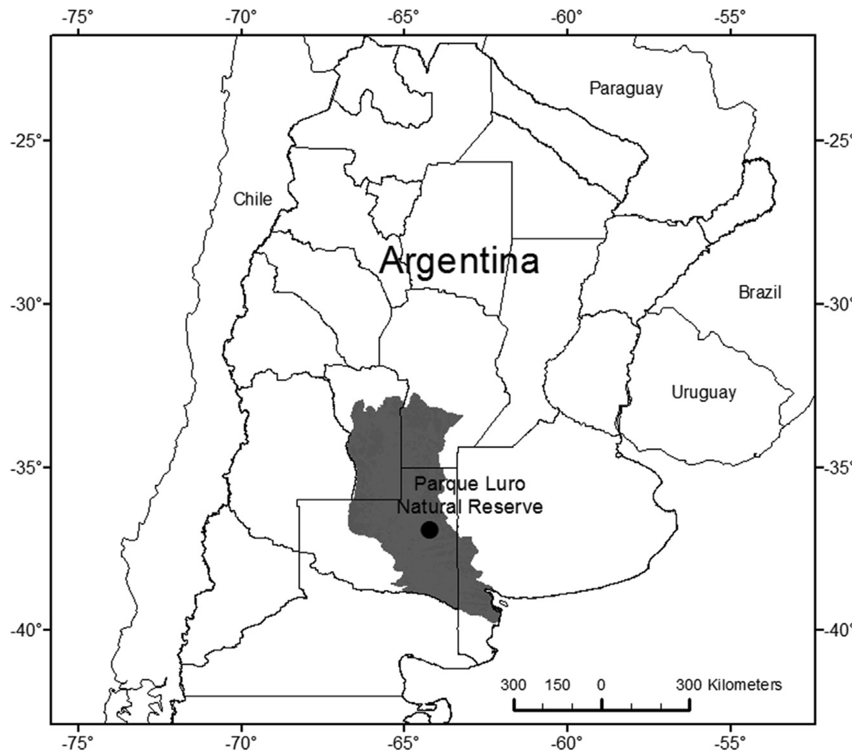

Fig. 1. Geographical location of the study area, the Parque Luro Natural Reserve (dot) and extent of the Espinal region of the Caldén forest (gray colored area).

Table 1
Prey items present in puma scat (n = 83) at the Parque Luro Natural Reserve (PLNR), central Argentina, between 2003 and 2004. Prey items are expressed as percent occurrence, and biomass consumed (%) estimated with the equation proposed by Ackerman et al. (1984), which uses the frequency of occurrence of prey in scat and the body mass of prey.

Prey item	Puma diet	
	% Occurrence	% Biomass
Mammalia		
Artiodactyla (subtotal)	**30.7**	**80.8**
Cervus elaphus	16.3	40.6
Sus scrofa	13.8	39.4
Ovis aries	0.6	0.8
Carnivora (subtotal)	**7.5**	**8.2**
Leopardus geoffroyi	6.3	6.8
Leopardus sp.	0.6	0.7
Conepatus chinga	0.6	0.7
Cingulata (subtotal)	**6.9**	**6.2**
Chaetophractus villosus	3.8	4.0
Zaedyus pichiy	3.1	2.1
Lagomorpha (subtotal)	**0.6**	**0.7**
Lepus europaeus	0.6	0.7
Rodentia (subtotal)	**13.7**	**1.0**
Akodon molinae	0.6	0.0
Graomys griseoflavus	0.6	0.0
Galea musteloides	2.5	0.3
Ctenomys sp.	6.9	0.6
Eligmodontia typus	2.5	0.0
Reithrodon auritus	0.6	0.0
Aves (subtotal)	**40.6**	**3.1**
Anatidae	0.6	0.7
Zenaida auriculata	21.2	1.0
Unidentified bird	18.8	1.4
No. of prey items	160	
No. of scats	83	

population estimations of abundance inside the PLNR, however individuals are commonly seen forming large groups throughout PLNR (Zanón Martínez, pers. obs.). In addition, large native herbivorous, such as the guanaco or the pampas deer (*Ozotoceros bezoarticus*), are locally extinct in our study area (Wilson and Mittermeier, 2011). Under these conditions, introduced ungulate populations could be closer to its ecological carrying capacity and hence highly available as prey for pumas.

Pumas also preyed on native species in the PLNR, so native predator-prey interactions are not completely disrupted, as it has been shown in a recent study conducted in PLNR where pumas play a key role in plant community dynamics through effective secondary dispersal of seeds initially consumed by pumas prey, the eared dove (Sarasola et al., 2016). However, puma native prey consumption was proportionally small, in spite of the widespread presence of small and medium native prey (small birds, armadillos, rodents and carnivores). Similarly, a different study showed that pumas preyed on introduced wild species and livestock in Quebrada del Condorito National Park in central Argentina. When livestock was removed from that area, pumas increased the consumption of native prey, such as rodents, small birds, and guanacos (Pia, 2013). Another study conducted in central Argentina showed a reverse situation, where a native medium size rodent (plains vizcacha) was the main prey item of the puma, but after plains vizcachas population collapsed, pumas shifted and increased introduced prey consumption (Branch et al., 1996). Our results are consistent with those previous findings. In our study area pumas are consuming more exotic prey than native prey, which could be the result of high exotic prey abundance in the community, and pumas are displaying a generalist and opportunistic behavior.

Considering our results, native predator-prey interactions in the PLNR are worrisome from an ecological and managerial point of view. We believe that urgent actions are needed in the management of PLNR. For instance, PLNR needs the reintroduction of large and medium native prey, and the eradication of exotic species. Moreover, the perimeter fence enclosure prevents the exit of red deer outside the park. During the 1980s the red deer populations were managed for the commercialization of its velvet, and to date, there has not been any other type of management on those population. Thus, controlling population growth of red deer and wild boar is at halt, which results in negative conservation impacts, by passively ensuring the permanence of exotic species within the PLNR, affecting puma-native prey interactions, and failing to comply with the objectives of a protected area.

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