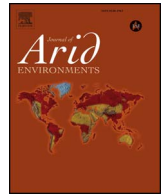




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Human-carnivore interaction in a context of socio-productive crisis: Assessing smallholder strategies for reducing predation in North-west Patagonia, Argentina

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ARTICLE INFO

Keywords:

Adaptive management
Command-and-Control
Husbandry practices
Network analysis
Socio-ecological systems

ABSTRACT

Mitigating carnivore-livestock interaction is essential to ensuring the persistence of carnivores in landscapes dominated by livestock activity. Our aim was to explore, in the context of social and productive crises triggered by environmental events, the values and attitudes adopted by smallholders in relation to wild carnivores. We performed semi-structured interviews on issues related to the management decisions of the productive system. To study the relative importance and associations among different factors, we constructed causal maps and used centrality measures based on network analysis to identify the dominant discourse. Although carnivores were perceived as one of the central problems of the map, retaliatory killing was not a central loss-prevention strategy. Smallholders turned to semi-intensification of livestock practices to increase the efficiency of their production as a response to different perceived problems. Lethal control techniques were weakly associated with a subsidized control system, which the state implements to stimulate the hunting of carnivores. Whereas policies were oriented to control native wild predators as the major source of disturbance, strategies of smallholders were based on adaptive responses to multiple perceived problems. This work provides new insights to improve the monitoring of mitigation measures to promote effective evidence-based policy.

1. Introduction

For decades the relevance of human-wildlife conflict has been recognised as a threat to biodiversity. Nevertheless, conservation biology is dominated by techniques associated with the ecology of the species involved (Dickman, 2010). In particular, human-carnivore conflict is a worldwide issue requiring policies aimed at managing both social and ecological pressures and interactions. Livestock production techniques should ideally adapt their socio-economic role to not only maximize production, but also to mitigate impacts on carnivore populations and their prey base (Treves and Karanth, 2003; Karanth and Chellam, 2009). The livestock sector emerges as one of the top two or three significant contributors to the most serious environmental problems, at every scale from local to global (Steinfeld et al., 2006). However, lethal control to reduce livestock depredation is the main cause of the decrease and extinction of many carnivore populations (Treves and Karanth, 2003; Baker et al., 2008; Inskip and Zimmermann, 2009;

Karanth and Chellam, 2009). Scientific literature is mainly dominated by conflict situations within protected areas and along their borders, especially when endangered carnivores are involved (Inskip and Zimmermann, 2009; Fourvel and Mwebi, 2011; Hazzah et al., 2014; Aryal et al., 2014, 2015). Mitigation strategies affecting non-threatened, common or abundant carnivores in agricultural landscapes have been less explored (Carter and Linnell, 2016). On the other hand, analyses focusing on competing factors (i.e. social, economic, environmental) driving perceptions and attitudes of smallholders toward carnivores are rare, in spite of their importance for subsistence economies and policy development programs (Dickman, 2010; Marchini and Macdonald, 2012; Carter and Linnell, 2016; Khanal et al., 2017; Panthi et al., 2017). Different environmental scenarios could modify producers' perceptions of their socio-ecological systems, and even predation mitigation practices can be adapted to specific or local cases (Baker et al., 2008; Carter and Linnell, 2016; Aryal et al., 2017).

Traditional action policies are still based on an oversimplification of

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<https://doi.org/10.1016/j.jaridenv.2017.12.005>

Received 5 July 2017; Received in revised form 7 December 2017; Accepted 11 December 2017

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the complexity of human-carnivore impacts (Aryal et al., 2016). In that way, carnivore management is frequently dominated by the logic of command-and-control management policies (i.e. linear relation between carnivore abundance and predation damage; Holling and Meffe, 1996). Various assumptions around human-carnivore impacts were formulated as shown in Dickman (2010): (a) damage level depends on the abundance of carnivores; (b) there is a linear relationship between the perceived level of damage by predation and the attitude of farmers towards carnivores; and (c) the socio-economic status of farmers is inversely proportional to the level of hostility in response to the damage inflicted by carnivores. Subsistence farmers would be more aggressive than commercial farmers (Romañach et al., 2007; Dar et al., 2009; Hazzah et al., 2009; Aryal et al., 2012a,b, 2014; Bista and Aryal, 2013). As a result of these assumptions, the oldest and most widely applied approach is lethal control of wild and feral carnivores. However, this practice is usually ineffective in reducing the conflict of livestock mortality due to predation (Berger, 2006; Treves et al., 2016). Command-and-control policies frequently promote linear responses to complex problems. They focus on external drivers (e.g. population dynamics, reproductive potential) in an attempt to reduce variability and increase productivity of systems. Nevertheless, many systems have expressed distress in response to the natural resources management: reduction of the natural variability of the system results in a concomitant loss of resilience to external disturbances (Holling and Meffe, 1996).

Facing the impact of predation, decision making by farmers is the result of multidimensional processes (Vanclay et al., 2006; White et al., 2009; Fairweather, 2010; Liu et al., 2011). Social, economic, cultural and environmental aspects interact at different spatial and temporal scales, influencing mental models, perceptions and decisions (Vanclay et al., 2006; Liu et al., 2011; Easdale and Domp tail, 2014). Cognitive mapping can make explicit social perceptions and discourses in relation to their farming systems, the interactions among different internal and external factors, and their influence or relationships with management decisions. Understanding these interactions is fundamental to promoting changes in management practices (Özesmi and Özesmi, 2004; Fairweather, 2010; Fairweather and Hunt, 2011) and improving policies on socio-ecological issues (Carter et al., 2012; Domp tail et al., 2013). A wildlife management framework should reduce livestock loss and facilitate coexistence with large carnivores. Therefore, mitigation response variables of further studies should directly measure these outcomes. Without such evidence, the capacity for management change is hindered, affecting both human livelihoods and the conservation of large carnivores (Van Eeden et al., 2017). For example, rising expenses in the population control of coyotes (*Canis latrans*) has not resulted in an improvement in the sheep industry, which is more influenced by market prices and production costs (Berger, 2006).

Between 2007 and 2012, the effects of a severe and long-lasting drought coincided with the abrupt deposition of volcanic ash from the eruption of the Puyehue-Cordón Caulle complex in northwestern Patagonia, Argentina. In Río Negro province, the combined effect of the drought and eruption caused a significant reduction in livestock production and, due to the widespread death of livestock, a socially and economically stressful situation (Easdale and Rosso, 2010; Easdale et al., 2014). Since 1972, in Río Negro, law 763 “fight against wild animal populations circumstantially harmful to livestock” (Law 763/72, from now on) has been enforced. This law established the creation of a fund for incentive payments, for the lethal control of pumas (*Puma concolor*) and culpeo foxes (*Lycalopex culpaeus*), US\$ 170.0 and US\$17.0 per hide, respectively. The fund is financed through a tax on the transport and commercialization of livestock products and is administered by the Ministry of Production of Río Negro. This provided a unique scenario within which we could assess whether a policy based on command-and-control logic (subsidized predator control) was effective for standardizing the behaviour of farmers (motivating lethal control) in a situation of disturbance (caused by drought and volcanic ash fall).

The aim of this study was to analyze the perceptions of smallholders in relation to livestock production loss and the strategies they adopted in the context of a severely stressful socio-productive situation in the region of northwestern Patagonia, Argentina. We also aimed to assess whether the predation mitigation strategies adopted by smallholders were aligned with the policies based on command-and-control logics. We seek to find the main perceived problems and the strategies adopted by smallholders to mitigate predation damage, and their relative importance regarding other identified problems and management strategies.

Considering the key assumptions of human-carnivore impacts, we hypothesized that (a) smallholders would perceive predation as one of the most relevant problems affecting their livestock, and (b) their main strategy to reduce predation damage would be associated with some kind of lethal control to reduce losses.

2. Methods

2.1. Study area

The study was carried out in a rural zone of Pilcaniyeu county, Río Negro province (−70.72191, −41.12280), situated in northwestern Patagonia, Argentina. This area is located in the Andes piedmont, which has a strong west-east annual rainfall gradient from 800 mm to 300 mm, respectively, concentrated in the winter. The average annual temperature is 8 °C. The plant community is characterized by grass-shrub steppes, dominated by *Festuca pallelescens*, *Pappostipa speciosa*, *Poa ligularis*, *Mulinum spinosum* and *Senecio* spp. (Leon et al., 1998). Extensive livestock farming, predominantly sheep raising, is the main economic activity in this region. Culpeo fox predation was reported to be the second most important cause of mortality in lambs in perinatal periods and was described as the main cause of mortality in 7 to 60-days-old lambs (Bellati and Von Thüngen, pers. comm.). The landscape encompasses patches managed by smallholders (< 5000 ha) interspersed with bigger areas owned by large sheep ranchers (> 10000 ha; Easdale pers. obs.). The large ranches are dedicated mainly to raising Merino sheep for the wool market. Although the sale of wool is also the main source of income for the smallholders, their systems tend to be more diversified. Other species, such as Angora goats and cross-bred cows, are also key to their livelihoods (Easdale and Rosso, 2010; Villagra et al., 2015). From 2007 to 2012, precipitation dropped to between 33 and 29% of the annual historic mean (444 mm; Easdale et al., 2014), leading to a prolonged drought. In June 2011, the Puyehue-Cordón Caulle complex (Chile) erupted, affecting the Pilcaniyeu County with the ash fall. As a result, a 1.5–5 cm layer of ash covered the area (Gaitán et al., pers. comm.). The volcanic ash severely reduced foraging availability, also producing multiple sanitary problems such as tooth wear, digestion disorders and even death owing to inaccessibility to water (i.e. water bodies were covered with ash; Robles et al., pers. comm.).

We defined the study area by restricting it to a zone with homogenous climatic and floristic conditions. We used GIS to superimpose cadastral layers, vegetation, georeferenced housing units and volcanic ash distribution (Gaitán et al., pers. comm.). Within the zone severely affected by ash deposits (ash layer greater than 3 cm, Fig. 1), we defined a patch dominated by smallholders. We decided to concentrate on smallholders because they are the most vulnerable to extreme environmental events (Morton, 2007). The identified patch had a total surface area of 36,636.0 ha, which contains 50 ranches (average area: 678.0 ha, range: 50–3000 ha).

Fourteen personal interviews were conducted with randomly selected smallholders, with 28% of the total smallholder population surveyed. In each case the study objectives were declared and interviews were carried out once participants provided their consent. All selected individuals agreed to participate. Interviews were performed by one individual (P. Gáspero) in Spanish and employed local terms to

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