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# The relationship between climate, diseases of domestic animals and human-carnivore conflicts

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## Abstract

Human-carnivore conflicts over livestock predation threaten biodiversity conservation and rural development, but the impact of climate and its change on such conflicts is insufficiently studied. The effect of climatic factors on diseases of predation-prone domestic animals and then on conflicts is unstudied, but potentially significant. This empirical case study addressed the conflict between people and leopards (*Panthera pardus*) in the Hyrcanian humid temperate forest (Iran). We analyzed our questionnaire and other data from all 34 villages around Golestan National Park in terms of probabilities of human-leopard conflicts over livestock predation, diseases of domestic animals and WorldClim bioclimatic variables. Using multiple predictive modeling approaches (generalized linear modeling GLM, Multivariate Adaptive Regression Splines MARS, Bayesian Belief Network BBN, BIOCLIM and DOMAIN), we show that climate continentality and precipitation patterns affect diseases, and more diseases lead to more conflicts. The Community Climate System Model (CCSM4) scenarios forecast aridization of the study area in 2041–2080 and a resultant decline of disease and conflict probabilities by 18.4–21.4% and 10.4–11.9%, respectively. We conclude that diseases can drive human-carnivore conflicts which may become less intense with projected aridization of the studied humid environment.

## Zusammenfassung

Konflikte zwischen Mensch und Raubtieren, die auf Prädation von Nutztieren basieren, stellen eine Bedrohung für den Schutz der Biodiversität sowie der ruralen Entwicklung dar. Einflüsse des Klimas und seines Wandels auf diese Systeme sind bisher nur unzureichend untersucht. Speziell der Einfluß klimabedingter Faktoren auf Krankheiten prädationsanfälliger Tiere und damit zusammenhängende Konflikte sind bisher nicht untersucht, aber potentiell von großer Bedeutung. Die vorliegende empirische Fall-Studie beschäftigt sich mit dem Konflikt zwischen Mensch und Leopard (*Panthera pardus*) in hyrkanischen humid-temperaten Wäldern (Iran). Wir untersuchten Datensätze aus eigenen Fragebögen und anderen Quellen von allen 34 Dörfern um den Golestan Nationalpark in Hinblick auf auf Prädation von Nutztieren beruhenden Mensch-Leopard Konflikten,

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Nutztier-Krankheiten sowie WorldClim bioklimatische Variablen. Wir zeigen hier unter Anwendung verschiedener prädiktiver Modellierungsansätze (verallgemeinerte lineare Modelle GLM, multivariate geglättete Regressionen MARS, Bayesian Belief Network BBN, BIOCLIM und DOMAIN), daß Klima-Kontinentalität und Niederschlagsmuster Krankheiten beeinflussen, wobei zunehmende Krankheiten zu mehr Konflikten führen. Szenarien des Community Climate System Modells CCSM4 sagen eine zunehmende Aridifizierung für das Untersuchungsgebiet im Zeitraum 2041–2080 voraus und einen daraus resultierenden Rückgang der Wahrscheinlichkeit von Krankheiten und Konflikten um 18.4–21.4% bzw. 10.4–11.9%. Wir schlussfolgern, daß Krankheiten Mensch-Raubtier-Konflikte beeinflussen können und daß diese mit künftiger Aridifizierung der von uns untersuchten humiden Region abnehmen könnten.


***Keywords:*** Climate; Conflict; Disease; Golestan; Iran; Leopard; Livestock; Model; *Panthera pardus*

## Introduction

Climate affects all aspects of biodiversity, from individual fitness to ecosystem functioning (Sheridan & Bickford, 2011). Particularly, in terrestrial mammalian carnivores climatic conditions make a dramatic influence on body and tooth size variation (Sheridan & Bickford, 2011; Szuma, 2008), distribution (Abade, Macdonald, & Dickman, 2014; Tôrres et al., 2012), population size (Trinkel, 2013), speciation (Mukherjee et al., 2010) and faunistic evolutionary turnover (Meehan & Martin, 2003). As climate changes, carnivores can influence other species and communities by top-down regulatory processes, such as trophic cascades, for example by boosting vegetation growth through suppressing herbivores (Ripple et al., 2014). Also, predation risk creates the "ecology of fear", which affects the behavior of ungulates and thus shapes the structure of ungulate and vegetation communities (Ripple et al., 2014). Due to their high mobility and tolerance to habitat characteristics, carnivores are most able to keep pace with climate change and even expand their ranges by occupying new favorable habitats and prey-rich areas (Kashkarov, Baranov, Pomortsev, & Ishchenko, 2008; Schloss, Nuñez, & Lawler, 2012). On the other hand, mountain-dwelling carnivores are prone to extinction because of the range shrinkage resulting from warming-triggered landscape and prey changes (Forrest et al., 2012). The same is expected to happen also with carnivores from maritime lowlands, where warming can lead to floods by raising sea level and increasing snowmelt rates at higher elevations (Seidensticker, 2008). Precipitation of the driest quarter has been the main determinant of the existence of carnivores in humid tropical forests, making their extinction imminent with increased seasonality and aridization (Wilting et al., 2010). Arctic biodiversity and particularly its top-level carnivores are extremely vulnerable to climate change due to ice melt, temporal and spatial shifts in species interactions and distributions, and related processes (Pacifici et al., 2015).

Climate can affect carnivores also indirectly by influencing threats. The major threat to carnivores is their conflict with humans for space and food (Ripple et al., 2014). This conflict is particularly widespread with seven big cats, i.e. tiger (*Panthera tigris*), lion (*Panthera leo*), jaguar (*Panthera onca*), leopard (*Panthera pardus*), snow leopard (*Panthera uncia*), cheetah (*Acinonyx jubatus*) and puma (*Puma concolor*), which kill domestic animals and sometimes even humans and thus inflict significant losses (Loveridge, Wang, Frank, & Seidensticker, 2010). Since most of these felids, except for puma, are globally threatened their retaliatory killing by people represents a major challenge for the synergy of rural development and biodiversity conservation, especially around protected areas (Inskip & Zimmermann, 2009). The impact of climate and its change on human-big cat conflicts is poorly understood and its limited conclusions are controversial. In some areas, cats kill livestock mostly during the wet season when wild prey disperses into reviving vegetation, regains fitness and thus becomes less available, whereas livestock enters these areas for uncontrolled grazing (Kolowski & Holekamp, 2006; Polisar et al., 2003). In other areas, the peak of livestock predation occurs in the dry season when limited cover decreases hunting success, wild prey moves away and livestock concentrates around a few waterholes (Dar, Minhas, Zaman, & Linkie, 2009; Schiess-Meier, Ramsauer, Gabanapelo, & König, 2007). This uncertainty can be aggravated by contradictory results from the same study areas (de Iongh & Bauer, 2008; van Bommel, Bij de Vaate, de Boer, & de Iongh, 2007).

As shown above, the effect of climate on conflicts has been considered through the mediating role of the availability of wild prey. However, other climate-driven factors such as diseases of predation-prone domestic animals may also contribute to conflicts. Diseases are widely known to be among the top problems for rural livelihoods (Dar et al., 2009; Kissui, 2008; Soto-Shoender & Giuliano, 2011), but the empirical research of their role in conflicts is still nascent (Khorozyan, Soofi, Hamidi, Ghoddousi, & Waltert, 2015).

In this paper, we address the relationships between climatic conditions and their change in the 21st century, diseases of domestic animals and human-leopard conflicts in Golestan National Park (Iran). This protected area accommodates the largest population of the globally endangered Persian leopard (*P.p. ciscaucasica* = *P.p. saxicolor*) which is under significant pressure of retaliatory killing by conflict-struck people