An uncertain future for the endemic Galliformes of the Caucasus

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HIGHLIGHTS

- Climate and land use change impacts were investigated for two endemic Galliformes.
- Future suitable geographic ranges were predicted to significantly shrink.
- Both species were "most vulnerable" to climate change in a vulnerability matrix.
- Urgent action is needed to preserve these flagship galliformes of the Caucasus.

GRAPHICAL ABSTRACT

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ABSTRACT

Impacts of climate change are already evident in ecosystems worldwide. High-latitude and altitude regions are at greatest risk because the effects of climate change are greater in these regions, and species from these areas have limited ability to track their climate envelopes. The Caucasian snowcock (*Tetraogallus caucasicus*) and the Caucasian grouse (*Lyrurus mlokosiewiczi*) are both high-altitude specialists that are endemic to a restricted range in the Caucasus mountains of Europe. Little research has been performed to determine the status of the populations or the potential impacts of climate change. We investigated how climate and land use change may impact both species in future and determined whether their life history traits may increase their vulnerability using a combined exposure and trait-based index. We compared several climate models, and in all instances, both species showed drastic range contractions although the extent of the contraction varied with each model. Traits like habitat specialism, ground nesting and incubation period meant that both species may be considered "most vulnerable" in the exposure and trait-based index. Given that both species already occur near the maximum elevations of the Caucasus, and that they lack any dispersal capabilities due to the isolation from alternative mountainous areas, research efforts need to be prioritized to improve our knowledge about their population status, to monitor future trends and to begin developing species action plans that conserve these endemic and iconic species of Europe. Both species are flagship and umbrella species and may serve as indicator species, their protection may therefore benefit a whole range of other species inhabiting this vulnerable Alpine ecosystem. Especially the Caucasian grouse has a high aesthetic value and is favoured by hunters in the region. The potential demise of this species may therefore also be negative for local communities.

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1. Introduction

Climate change is expected to affect many species, be it in their abundance, distribution, phenology or physiology (Sala et al., 2000; Thomas et al., 2004; Urban, 2015). With ongoing climate change, climate niches are generally shifting to higher latitudes and altitudes and are becoming dissimilar compared to previous conditions (Williams et al., 2007). The survival of species is therefore dependent on their capacity to adapt to new climates or to track their current climatic niches (Parmesan et al., 1999; Walther et al., 2002). Species that inhabit high-latitude regions and mountain ecosystems are predicted to be affected more by climate change than species inhabiting many other ecosystems (ACIA, 2004, IPCC, 2013). Species occurring in these ecosystems have adapted to climates that in future will either have severely reduced geographically or will no longer exist. The rate of increase of temperatures in mountainous areas is for instance projected to be up to three times higher than the rate of increase recorded during the past century (Nogués-Bravo et al., 2007). Studies predict that especially the species adapted to conditions at higher elevations will be threatened by changes in temperature and precipitation regimes (Engler et al., 2011) and mountainous areas throughout the world are already affected by climate change (Pounds et al., 1999; Engler et al., 2011).

Mountain ecosystems are frequently considered as biodiversity hotspots (Orme et al., 2005) meaning that the negative effects of climatic change on these ecosystems may impact a disproportionate number of species. Furthermore, the number of endemic species generally increases with increasing elevation (Kessler, 2002; Vetaas and Grytnes, 2002; Fu et al., 2006), species endemic to high elevations may therefore be at greater risk of extinction. Therefore, a relatively large proportion of endemic species are predicted to go extinct in future due to climate change (Malcolm et al., 2006; Thuiller et al., 2006). In addition to exposure to climate change, several natural history traits of, amongst others, high elevation species, such as thermal tolerance, rarity, habitat specialism and ground nesting behaviour (Deutsch et al., 2008; Foden et al., 2013; Hof et al., 2017), may also make them increasingly vulnerable to climate change.

The Caucasian grouse (*Lyrurus mlokosiewiczi*, henceforth referred to as grouse) and the Caucasian snowcock (*Tetraogallus caucasicus*, henceforth referred to as snowcock) are two of the few endemic European bird species. Both species are so-called flagship and umbrella species in the Caucasus, which means that their protection could benefit other species that share the same habitat and threats (Roberge and Angelstam, 2004; Zazanashvili and Mallon, 2009). The grouse is currently assessed as Near Threatened on the IUCN red list of threatened species (BirdLife International, 2016). Its distribution range comprises around 321,000 km^2 according to BirdLife International (2016), but considerably lower estimates (12,000 km^2) have also been reported (Gokhelashvili et al., 2003). The current population trend of grouse is listed as decreasing due to hunting, overgrazing, wood cutting, and habitat fragmentation (Gokhelashvili et al., 2003; BirdLife International, 2016). The snowcock is currently assessed as Least Concern on the IUCN red list of threatened species (BirdLife International, 2017). The current population trend of snowcock is stable. However, its distribution range is smaller than that of the grouse according to BirdLife International (2017), with a range of around 62,600 km^2. Both species are endemic to the Caucasus Mountains (see Fig. 1). The grouse inhabits areas at or near the tree line and prefers open habitat (Gokhelashvili et al., 2003; Gavashelishvili and Javakhishvili, 2010), and the snowcock inhabits alpine slopes between the tree-line and the snow-line (McGowan et al., 2018). Since both species inhabit mountainous regions, which may be strongly affected by climate change in future, and both species have several traits that are associated with increased vulnerability to climate change, it is important to assess their vulnerability to climate change. Some work has been done on the grouse; e.g. its potential distribution in Turkey has been modelled (Gottschalk et al., 2007), and its nesting habitat and landscape requirements have been studied (Gavashelishvili and Javakhishvili, 2010; Habibzadeh et al., 2013). However, to date hardly any research has been done on the snowcock, despite its endemicity (Murray et al., 2015). Both species may well face range contraction and possibly even extinction in a future warmer climate. Since both species are flagship and umbrella species and several other members of the Galliformes have been identified as indicator species, the potential loss of these endemic species may
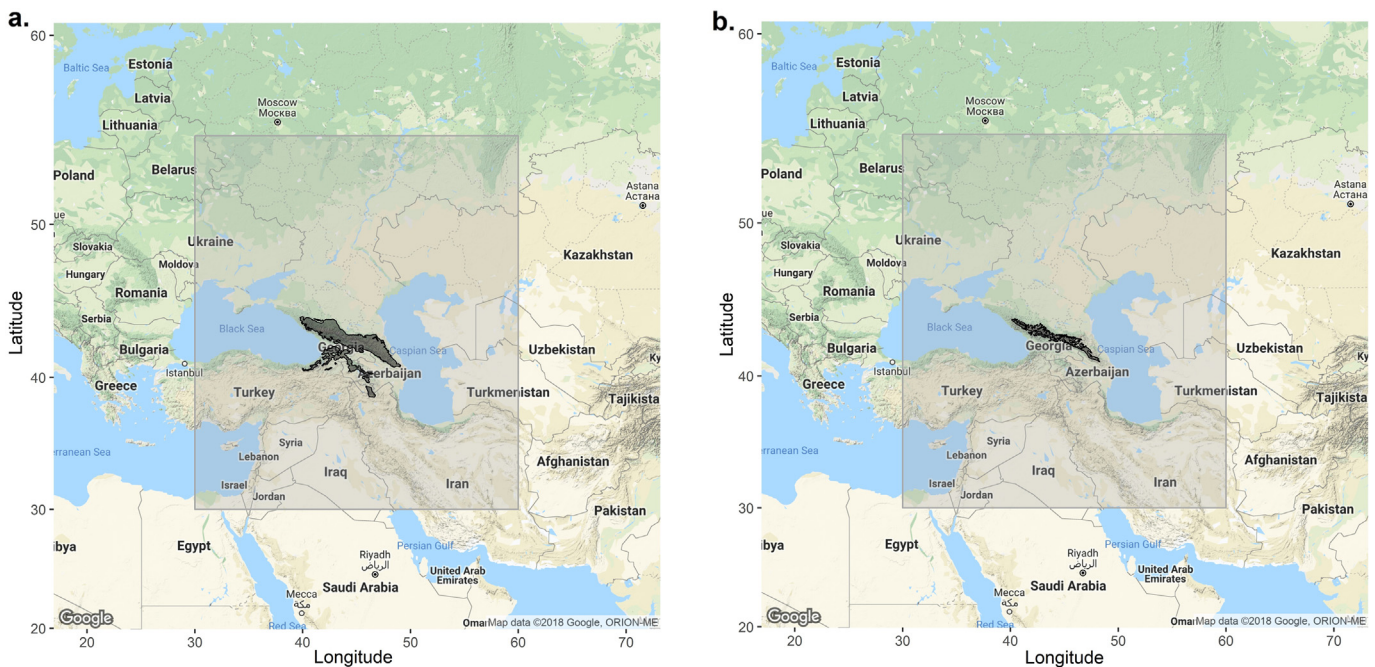
Fig. 1. a) The current range of the Caucasian grouse as defined by the IUCN (BirdLife International, 2016) in dark grey and the geographical extent used to train the model displayed by the lighter grey box, b) The current range of the Caucasian snowcock as defined by the IUCN (BirdLife International, 2017) in dark grey and the geographical extent used to train the model displayed by the lighter grey box.