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Apex scavenger movements call for transboundary conservation policies

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ABSTRACT

Current changes in the environment and increases in threats to wildlife have prompted the need for a better understanding of species' conservation requirements. Strategies for the conservation of large-sized animal species with large home ranges have included the creation of large protected areas, or for migrants, the creation of protected breeding, stop-over and wintering areas. We aim to describe the movement behaviour of Andean condors (*Vultur gryphus*), and to relate it to its significance in the conservation of this species and its environment. We examine whether current conservation strategies are sufficient to ensure the daily requirements of the species, and evaluate the degree to which breeding and foraging areas are covered by protected areas. We present as a new challenge the conservation of large-sized species that perform daily long-range movements across a number of political and ecological borders. Andean condors tagged with GPS-satellite transmitters make long daily flights from their breeding areas (mountains in Argentina and Chile) to their feeding areas (the steppe in Argentina) crossing over the Andean Cordillera. These flights demonstrate that current conservation strategies are insufficient to protect species with such daily movement patterns, and that new approaches are needed. Thus, it is necessary to gain a more in-depth knowledge of the movement ecology of these organisms through individual-level approaches integrating intrinsic (reproductive and foraging behaviour) and extrinsic (political and geomorphological boundaries) factors that shape movement patterns. Conservation efforts must include international cooperation aiming to combine the conservation of flagship species, the management of public and private lands, and the maintenance of valuable ecosystem services.

1. Introduction

Under the current extinction crisis, conservation policies that transcend political boundaries are indispensable in dealing with large-scale conservation issues (Abbitt et al., 2000; Donald et al., 2007; Barnosky et al., 2011). It is indisputable that the size of a protected area is key to ensuring the maintenance of populations, ecosystems and ecological processes (Dudley, 2008). However, the conservation of wide-ranging species that move between countries or even between continents poses challenges that exceed these common approaches (Wilcove and Wikelski, 2008; Block et al., 2011).

Conservation of wide-ranging vertebrates, such as large mammals, usually focus on the maintenance of strictly protected areas with a general criterion of 'bigger is better' (Wielgus, 2002; Du Toit et al., 2003; Thirgood et al., 2004; but see Press et al., 1996). Although effective in some cases, those strategies may not be appropriate for flying organisms (birds, bats, insects), able to move over huge distances. This is especially true for migratory animals alternatively occupying spatially distant breeding and wintering grounds. In such cases, conventions for coordinated conservation strategies in the two extremes of the distribution areas and, in some cases, also at stop-over points along migration routes, are mandatory (Milner-Gulland et al., 2011). Other species, on the other hand, do not migrate but travel large distances over short time periods and are continuously exposed to changing threats. Their patterns of movement have not been well considered in conservation efforts.

Here, we call attention to the necessity of implementing new models of transnational strategies for the conservation of large vertebrates that perform long-distance movements on a daily basis. This is the case of avian scavengers, the largest flying vertebrates on the planet, whose populations are increasingly endangered potentially triggering the loss of key ecosystem services

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(Ferguson-Lees and Christie, 2001; Markandya et al., 2008; Ogada et al., 2012). Our study model was the Andean condor (*Vultur gryphus*), a large body-size top scavenger with astounding flight capacities (De Martino et al., 2011; Ferguson-Lees and Christie, 2001; Shepard et al., 2011). Conservation programs for these birds have mainly focused on reintroduction strategies (BirdLife International, 2012; Lambertucci et al., 2013). However, specific conservation designs considering their pattern of movement and home ranges are lacking. Our aim was to describe the movement behaviour of Andean condors and relate it to its significance in the conservation of this species and its environment. We also evaluate the degree to which breeding and foraging areas are covered by protected areas. In particular, we examine whether current conservation strategies, mainly based on the protection of pristine ecosystems, are sufficient to ensure the daily requirements of a population distributed in two countries (Argentina and Chile) along either side of the Andean Cordillera.

2. Methods

2.1. Study species

The Andean condor inhabits the Andean Mountains throughout South America and adjoining hills in central Argentina (Ferguson-Lees and Christie, 2001). It is among the largest flying birds in the world, with a 3 m wingspan and a weight of up to 16 kg. Condors are at the limit of flight capacity due to their size and weight (Pennycuick and Scholey, 1984; Shepard and Lambertucci, 2013). This species, considered as 'Nearly Threatened' worldwide and endangered in several countries, is exposed to several human-related threats (Carrete et al., 2010; BirdLife International, 2012; Lambertucci et al., 2011, 2012). Poisoning, including lead contamination, and persecution are among the main threats to which condors are exposed (Ferguson-Lees and Christie, 2001; Lambertucci et al., 2011). It is therefore plausible that they are at higher risk in their foraging areas due to those threats. However, some human disturbances in the breeding areas have also been observed (Lambertucci and Speziale, 2009).

2.2. Study area

We worked in the southern tip of South America (36–44°S, 69–73°W, Fig. 1), central Patagonia (Argentina and Chile). This area consists of a gradient that encompasses two major biogeographic units, the austral forest and the steppe (from west to east), including the transition region referred to as the forest–steppe ecotone (León et al., 1998). Ecotone and steppe areas have been used for extensive livestock ranching since the last century and they currently hold large numbers of alien mammal herbivores (Brown et al., 2006; Speziale et al., 2012). Condors use the area to feed mainly on domestic and wild herbivores (Lambertucci et al., 2009). A very low proportion of the steppe biome is protected (about 4%), with <1% being National Park (Brown et al., 2006). The west (both the Argentine and Chilean slopes of the Andes) is dominated by woodlands with a large number of cliffs that may be used for breeding. This latter biome is relatively well-protected in Chile and very well-protected in Argentina (10% and 34% of its total surface area, respectively) (Brown et al., 2006; Lara et al., 1996).

2.3. Bird tagging and data collection

During austral spring 2010 and 2011, twenty adult Andean condors (11 females and 9 males) were trapped with baited cannon net traps around the city of Bariloche. Birds were fitted with GPS tags (10 birds with patagial PTT-100 50 g Solar Argos/GPS tags, Microwave Telemetry Inc., and 10 with backpack 100 g Solar GPS–GSM CTT-1070-1100 tags, CellTrack Tech.). GPS tags were duty cycled to transmit every day from dawn to dusk at the maximum interval allowed by the unit (every 60 min for PTT tags, and every 15 min for CTT tags). Those tags collected data points corresponding to the coordinates through which each bird passed every day, throughout the months.

Condors were monitored continuously after release. To standardize the monitoring periods, we restricted our analyses to the first six months of monitoring of each bird. Because all the captures were done in spring, this period corresponds to spring-autumn. We obtained 49,022 GPS fixes from the 20 tagged breeding adult condors. All of those fixes were used to determine the land areas covered by the condors regarding their location by country, province, municipality, habitat and protected area size and IUCN category (Categories: (Ia) strict nature reserves, (Ib) wilderness area, (II) National Park, (III) natural monument or feature, (IV) habitat/species management area, (V) protected landscape/seascape; and (VI) protected area with sustainable use of natural resources; (Dudley, 2008)). We also used the fixes to locate breeding and foraging areas, and to estimate distances flown and home ranges.

2.4. Data analyses

Home ranges were calculated as the minimum convex polygons projecting all the fixes into ArcGIS 9.3© and ArcView 3.2© (ESRI Inc., USA). The distance flown each day by a condor was estimated from the sequential straight-line distance between fixes for each day.

Some birds visited both Argentina and Chile, and thus the time spent by the birds in each country was estimated using the selection by location feature of ArcGis 9.3©, as the number of fixes and days within each country. In order to count the number of times the international border was crossed, we first created a 4-km buffer area on each side of the international boundary. We then considered birds to have crossed this international border if they crossed the buffer zone. This was done to avoid the inclusion of data from birds that were flying close to the limit but without crossing it for more than a few kilometres. We chose this buffer since it corresponds to the area surrounding the nest in which condors may be flying while they are in the breeding area, and because some birds were nesting close to the international border and crossed it frequently. We assumed that when they flew more than this distance, it was because the bird was leaving the area.

Breeding areas were determined by the distribution pattern of fixes (coordinates), as the places with the highest concentration of dots in an area of 2-km radius, and were then corroborated in the field. We calculated the number of breeding areas inside protected areas by counting all the nesting areas that fell within the polygon of all the national protected areas in the region. We estimated the time that a bird was foraging outside protected areas first by projecting all data points of the twenty birds that fell within the polygon corresponding to the steppe area. We then estimated the proportion of data points that fell within the steppe biome, and at the same time outside of protected areas. The steppe was a good surrogate of the foraging area since condors do not eat in woodlands; we have observed dozens of carcasses consumed by condors and all of them were located in the steppe and GPS data showed that condor fixes are dispersed and birds spend time on the ground almost exclusively in the steppe.

3. Results

Taken together, all tagged condors flew over an area of 90,843 km^2, and the maximum flight distance for a bird was