ARTICLES

Some results of research on the Cinereous Vulture *Aegypius monachus* in Georgia

A. Gavashelishvili & M.J. McGrady

Summary

A model of Cinereous Vulture nesting habitat in Georgia was derived using GIS and remote-sensing that suggested the expansion of nesting habitat in Georgia over the past 15 years, which is likely related to the decline in seasonal human presence in these areas since the break-up of the Soviet Union. Radio-telemetry showed that a young Cinereous Vulture ranged over huge areas, fledging in Georgia, flying south to central Saudi Arabia, returning to its natal site, and then flying north over 500 km into Russia.

Introduction

In Georgia, the Cinereous Vulture *Aegypius monachus* breeding is restricted to the south-east (Abuladze *et al.* 1995, Abuladze & Shergalin 1996, Galvez *et al.* 2005, Gavashelishvili 2005, Gavashelishvili *et al.* 2006), where they nest in mature juniper trees *Juniperus communis*. Historical data on population trends are generally lacking, but earlier surveys estimated the vulture population at 17–20 (Abuladze *et al.* 1995, Abuladze & Shergalin 1996) and 20–30 (BirdLife International 2004) nesting pairs with a declining trend. In spite of some efforts to promote conservation, including the modelling of nesting and foraging habitats (Gavashelishvili 2006, Gavashelishvili & McGrady in press), the protection of the species in Georgia is not enforced, and there are no conservation-motivated supplementary feeding efforts. Fortunately, in Georgia, vultures, including the Cinereous Vulture, are not considered pests or competitors for resources important to humans, and persecution is limited to occasional shooting.

We counted the current number of breeding Cinereous Vulture pairs in Georgia, refined an existing model of their nesting habitat (Gavashelishvili *et al.* 2006) and compared availability of potential nesting habitat 15 years ago to current availability. We also initiated satellite-received telemetry work to gain insight into ranging behaviour and, to a limited extent, mortality. The extent of individual ranging is important information when identifying and estimating the availability of resources.

Study area and methods

Estimating population trend

In 2002 we conducted breeding vulture

surveys in south-eastern Georgia. Research conducted by us during 1998–2002 (Gavashelishvili *et al.* 2006) resulted in a model of nesting habitat (hereafter 'Model 1') suggesting that in Georgia a 20 x 20 m plot was more likely to contain a Cinereous Vulture nest if the slope was > 30° and faced north, was situated in rugged terrain away from unprotected and populated areas, and was relatively dry. This is mathematically defined as:

$$P_{cv} = 1/[1 + e^{-(11.925 \ln(\text{RUGGEDNESS}) + 4.31 \cos\alpha + 1.948 \ln(\text{GRAZE}+1) + 0.001\,\text{DPOP} - 15.98 \ln(\text{RAINFALL}) - 20.773)}]$$

Where:

P_{cv} = The probability of Cinereous Vulture nest presence in a 20 x 20 m plot.

e = The base of the natural logarithm (e = 2.71828)

ln =The natural logarithm

RUGGEDNESS = Total length (m) of 100 m elevation contours within a 500 m radius of the centre of a 20 m plot.

cos α = Cosine of aspect (compass bearing) of a 20 m plot, increasing from south (-1) to north (+1).

GRAZE = Distance (m) to the nearest point of unprotected areas that were exposed to grazing.

DPOP = Distance (m) to the nearest hut, house, or any building occupied by humans

RAINFALL = Annual rainfall (mm) within a 20 m plot.

Figure 1 shows the distribution of potential Cinereous Vulture nesting habitat as determined by Model 1. North-facing slopes are where suitable nest trees could be found, while ruggedness, protected areas and remoteness from populated areas make access to the nest trees by humans difficult. Low annual rainfall provides better soaring and breeding conditions. Model 1 suggested that the breeding range of the Cinereous Vulture in Georgia could expand if seasonal grazing, which is the primary source of disturbance, is properly managed. Because neither nesting places nor food availability appeared to be limiting factors, human disturbance and climate seem to explain best the current distribution of nesting Cinereous Vultures in Georgia, and probably elsewhere in the Caucasus.

However, as northerly aspect did not necessarily account for the presence of nesting trees and vegetative cover (because trees may have been felled), the map of potential distribution resulting from Model 1 also predicted nesting potential in the south-west of Georgia (Figure 1), where there were no mature trees for nesting during our study. To refine Model 1, we modelled suitable cover for nesting, using the distribution of existing nesting and reflectance values from Landsat 5 and 7 Thematic Mapping bands: 1, 2, 3, 4, 5, and 7. To do so, we used Mahalanobis distance (D^2), which is a multivariate statistic that describes a measure of dissimilarity, and is used in habitat modelling (Rao 1952, Clark *et al.* 1993). In our analysis D^2 was calculated as:

$D^2 = (x - m)^T C^{-1} (x - m)$

Where:

x = Matrix of reflectance value of each Landsat band at a given 30 x 30 m plot

m = Matrix of mean reflectance value of each Landsat band at plots with cinereous vulture nests

C^{-1} = Inverse covariance matrix of reflectance values of Landsat bands at plots with Cinereous Vulture nests

T = Indication of the matrix transposition

Thus, low D^2 values indicate conditions similar to those of the original sampling points (i.e. where nests occur), and increases in D^2 values indicate increasingly dissimilar conditions. We calculated D^2 at the scale of 30 x 30 m plots using a Mahalanobis distances extension for ArcView 3.x (Jenness 2003) for the entire area of Georgia (70,000 km^2). The resulting map of D^2 values was converted into a map of potential Cinereous Vulture nesting distribution based on a threshold value below which the values of plots with nests fell. This Landsat-based map of potential nesting was then multiplied by that of Model 1 to get the final refined map that would consider vegetation cover (i.e. Landsat reflectance) as well.

To determine whether the availability of potential nesting habitat had changed over the last 15 years we compared a predictive map of current vulture distribution derived from Model 1 and Landsat 7 TM taken in September 2002 to a map derived from Model 1 and Landsat 5 TM taken in September 1986. Using a nearest-neighbour distance of 440 m (Gavashelishvili *et al.* 2006) we calculated the potential number of pairs that would fit into the potential breeding habitats for the two time periods.

Radio-telemetry

We fitted a nestling Cinereous Vulture with an 80-g battery powered satellite-received transmitter (PTT, North Star Science and Technology, LLC, Baltimore, MD, USA) on 18 July 2004 in Chachuna Sanctuary, and used Argos satellite system for tracking. Argos assigns an accuracy index (location class or LC) to each location (Argos 1996); plausible locations are designated as LC 3, 2, 1, 0, A and B. Nominally the accuracy is <150 m for LC-3, 150–350 m for LC-2, 350–1,000 m for LC-1 and >1,000 m for LC-0. We imported Argos locations into ArcView using the Argos Tools extension (Potapov & Dubinin 2003). Because the accuracies of LC-0 and LC-B locations are much more variable (Britten *et al.* 1999, Vincent *et al.* 2002), we used only LCs-3, 2, 1, and A, when mapping the vulture's movements.

Results

Estimating population trend

We determined that there were 20 breeding pairs of Cinereous Vultures in Georgia in 2002, all in the south-east. The predictive maps based on combining Landsat data and data derived from Model 1 provided an enhanced map of the distribution of potential plots suitable for nesting and removed the misclassified potential breeding area in south-western Georgia (Figure 2).

A comparison of the resultant maps for the two time periods suggests that the area of suitable nesting habitat has grown since 1986. The number of breeding pairs was estimated to be 14 in 1986 and 22 in 2002, with the latter figure being close to the current total of 20 pairs found during field surveys.

Radio-telemetry

Soon after fledging, the bird started to move south on 15 November 2004, crossed Azerbaijan and Armenia (15 November 2004 to 23 November 2004), Iran (24 November 2004 to 8 December 2004), Iraq (8 December 2004 to 25 December 2004) and stopped in central Saudi Arabia (26 December 2004 to 20 March 2005). It started moving north on 18 March 2005, crossed Iraq (20 March 2005 to 25 March 2005), Iran (25 March 2005 to 4 May 2005), Armenia and Azerbaijan (6 April 2005 to 10 April 2005) and returned to its natal site in Georgia (11 April 2005). On 13 May 2005, the bird flew north into Russia to a place about 196 km west of Astrakhan, where it stopped transmitting on 17 July 2005 (Figure 3). We have not determined why transmissions ceased.

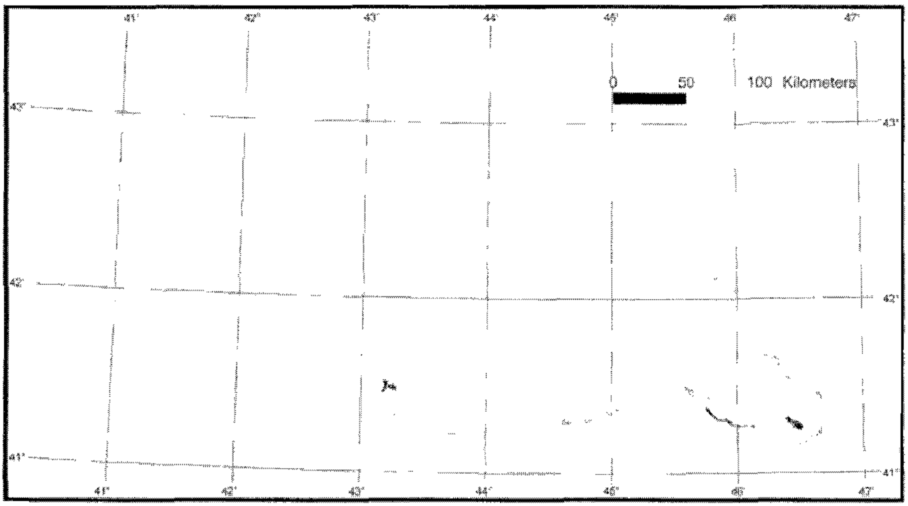

Figure 1. The distribution of potential Cinereous Vulture nesting habitat in Georgia, derived from a logistic regression model (Gavashelishvili *et al.* 2006).

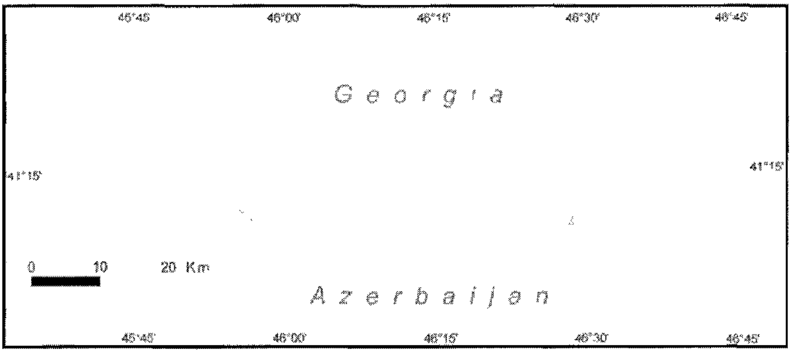

Figure 2. The distribution of potential Cinereous Vulture nesting habitat in Georgia in 2002, refined by using Landsat TM images.

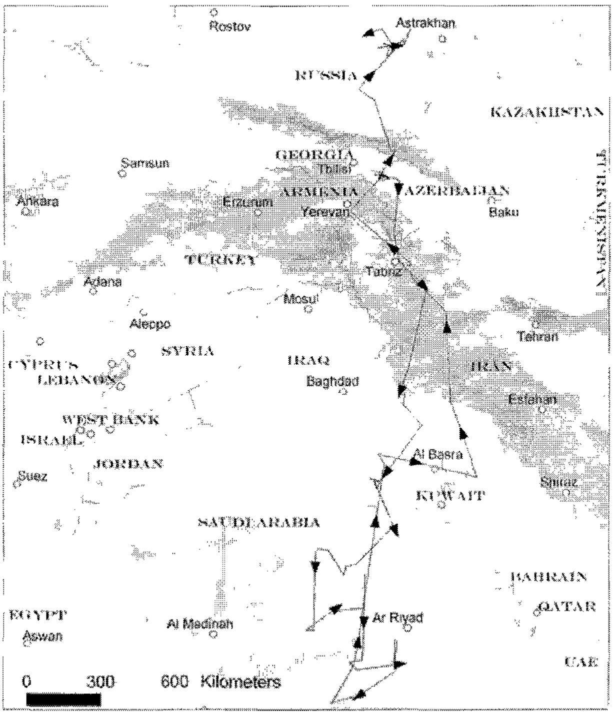

Figure 3. Movements of a Cinereous Vulture that was tagged as a nestling with a satellite-received radio-transmitter on 18 July 2004 (Chachuna Sanctuary, Georgia). The last signal was received on 17 July 2005.

Discussion

Our modelling suggests an expansion of Cinereous Vulture nesting habitat in Georgia over the past 15 years, which is likely due to decreases in numbers of livestock and the concurrent reduction in the number of winter camps used by shepherds (i.e. populated areas) within the Georgian breeding range. Before the break-up of the Soviet Union, sheep rearing was well subsidized and encouraged, and husbandry involved seasonal movements between summer and winter pastures. This meant there were many winter camps and consequently human disturbance was higher than it is today. Human disturbance during winter herding, including direct persecution, destruction of nest trees for firewood, and unintentional disturbance, are the factors most likely to affect Cinereous Vultures in Georgia, especially in light of their nests being built in low trees (Gavashelishvili *et al.* 2006).

Satellite-received radio-telemetry of a single bird illustrates just how far juveniles and immature birds may wander. Because this bird was tracked for a short period it may be the case that Cinereous Vultures in fact move over even larger areas before reaching maturity and establishing their breeding areas. However, one must be cautious in assuming how representative these data are. This research is on-going, and the radio-marking of more birds will reveal more about ranging behaviour, seasonal movements, juvenile dispersal, speed of travel, potential interactions among individuals in time and space and, to a limited extent, mortality.

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Authors' addresses: A. Gavashelishvili, Georgian Center for the Conservation of Wildlife (GCCW), P.O. Box 56, Tbilisi 0160, The Republic of Georgia. E-mail address: kajiri2000@yahoo.com McGrady, M. J., Natural Research, Ltd. Perth, Scotland.