ARTICLES

Radio-satellite telemetry of a territorial Bearded Vulture Gypaetus barbatus in the Caucasus

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Summary

In 2002-2004 we tracked a territorial, adult, female Bearded Vulture ***Gypaetus barbatus*** using a satellite-received transmitter in the Republic of Georgia, during which time she reared two fledglings in three breeding seasons. The temperature of the transmitter was significantly greater and less variable at night than during the day. These characteristics can be used to determine whether the transmitter is functioning on a living bird, and supplements information from PTT activity sensors. The 95% kernel home range covered 206 km2 at 1806–3736 m a.s.l. in a sparsely wooded area that was sparsely populated by humans. Minimum monthly biomass of dead livestock, East Caucasian Tur ***Capra cylindricornis*** and ***Chamois Rupicapra rupicapra*** within this range was estimated to be 1178 kg, and greatly exceeded the requirements of the vultures.

Introduction

The Bearded Vulture ***Gypaetus barbatus*** is considered “Near-threatened” globally (del Hoyo ***et al.*** 1994). Population declines have been most apparent in central Europe and Africa. In Europe, reintroduction and other conservation methods have been used to aid the species’ recovery.

The Argos satellite system is widely used to track animals globally, the results of which can help manage wildlife (Fancy et al. 1988, Argos 1996). Satellite-received transmitters (platform terminal transmitters or PTTs) fitted to animals transmit a signal that contains coded information about the animal and the status of the transmitter, including PTT temperature. The uplink signal is also used by the system to calculate the location of the transmitter using the Doppler shift in its frequency. The system assigns an estimate of accuracy, the location class (LC), to each location. Nominally the accuracy is <150 m for LC-3, 150-350 m for LC-2, 350-1000 m for LC-1 and >1000 m for LC-0. Argos is unable to estimate accuracy for LC-A, B or Z locations. Britten ***et al.*** (1999) discusses in detail the meaning of the location classes.

Location errors fall under a bivariate normal distribution (Clark 1989, Argos 1996), so theoretically 68% of the locations are within 226 m (LC-3), 528 m (LC-2) or 1510 m (LC-1) of the true location (Keating ***et al.*** 1991). Locational errors increase with PTT elevational error (i.e. the difference between the user-provided elevation and true PTT elevations) and the distance to satellite ground track. Also, terrain ruggedness reduces the time of satellite visibility, which causes a failure in calculation of PTT locations or their accuracy.

We present characteristics of a Bearded Vulture's home range, as well as data on the relation between PTT temperature and vulture behaviour. We know of no other peer-reviewed published information on radio tracking of Bearded vultures, though information is available on the internet (e.g.http://www.wild.unizh.ch/bg/sat/s_frame.php?bi=0&bg=0&ya=0&la=e&th=sat&st=1&su=0, last visited 2 November 2005).

Methods

Using Victor#3 Soft Catch leg-hold traps set around a Goat ***Capra hircus*** carcass, an incubating female Bearded Vulture (5.5 kg) was captured a few days before hatching (8 March 2002), c. 2 km from its nest in the Greater Caucasus of Georgia (Figure 1), and fitted as a backpack with an 80 g battery powered PTT (North Star Science and Technology, LLC, Baltimore, MD, USA), which had a duty cycle of 8 hrs on, 32 hrs off, using Teflon ribbon (Kenward 2001). The tag functioned for 976 days and transmitted for 4680 hrs.

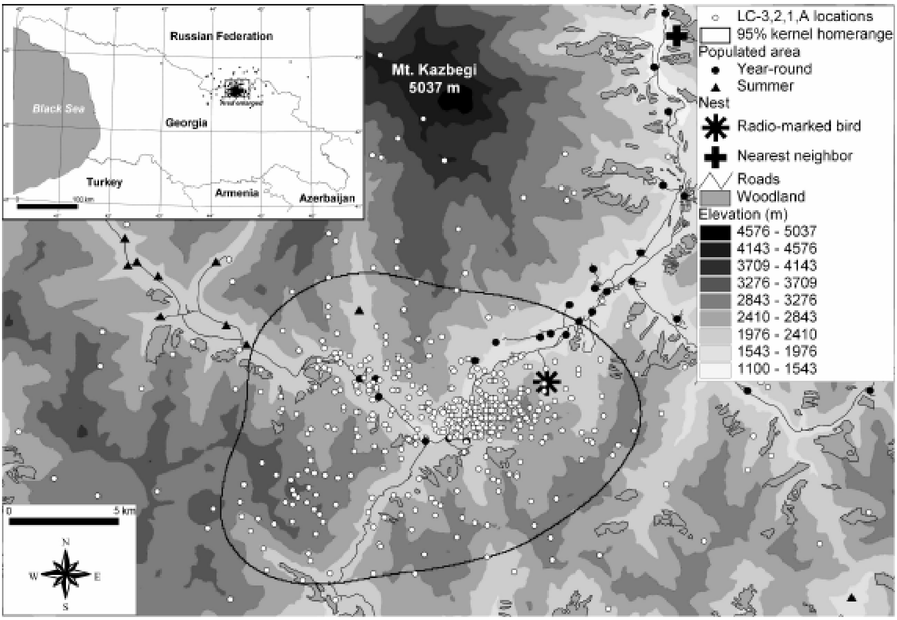

Figure 1. Home range (95% kernel) of an adult female Bearded Vulture in the Republic of Georgia tracked via satellite.

PTT temperature

Information on PTT temperature is included in each transmission. We decoded and filtered the sensor data for errors using software, DSDCODE1, provided by the manufacturer. Student's ***t***-test examined difference in temperature between daytime and nighttime locations. Levene's test was used to determine whether the assumption of equal variances could be made in the Student's t calculations.

Argos locations

We used the ArcView 3.3 (ESRI, Redlands, CA) Geographical Information System (GIS) to manage and analyze geographical data, and imported PTT locations into ArcView using the Argos Tools extension (Potapov & Dubinin 2003). Because the accuracy of LC-0 and LC-B locations are more variable (Britten ***et al.*** 1999, Vincent ***et al.*** 2002), we used only LCs-3, 2, 1, and A to estimate the bird's home range. We derived a 95% fixed kernel home range (Worton 1989) using the least squares cross validation within the Animal Movement extension to ArcView (Hooge & Eichenlaub 1997).

Home range characteristics

Variables related to climate, terrain, human disturbance, and food availability were measured within the kernel home range. Climate data were extracted from Khatiashvili ***et al.*** (1989). Terrain data were extracted from updated digital topographic maps (1:200 000, Headquarters of Geodesy and Cartography, under the Council of Ministers of the USSR, 1968, Facility No. 11).

Within the kernel home-range, all livestock (Sheep ***Ovis aires***, Goat, Pig ***Sus scrofa***, Cattle ***Bos taurus***, Horse ***Equus caballus*** and Donkey ***E. asinus***) were extensively husbanded; their numbers varied seasonally because of migratory pasturing, and dead animals were dumped away from populated areas. Numbers of livestock, and estimates of mortality rates and weights were obtained by interviewing local farmers and herdsmen (Table 1). Minimum monthly biomass for each livestock species was estimated as:

$$[(N_{juv.}M_{juv.}W_{juv.})+(N_{immat}M_{immat}W_{immat})+(N_{adult}M_{adult}W_{adult})]/12,$$

where N is the minimum number of animals, M is the mean annual mortality and W is mean weight. Total carcass biomass was calculated by summing monthly biomass of dead livestock for each populated area within the home range. Human population within the home range also varied seasonally, and the estimated maximum number of people within the home range was determined from interviews of local farmers and shepherds.

Table 1. Mean weight (kg), mean annual mortality (%), and minimum numbers of livestock in the home-range of a Bearded Vulture tracked via satellite.

Livestock type	***Juvenile***	***Immature***	***Adult***
Sheep and Goat	10 kg	20 kg	30 kg
	21%	5%	6%
	114	81	50
Pig	19 kg	60 kg	90 kg
	14%	3.4%	4.2%
	150	107	66
Cattle	65 kg	200 kg	300 kg
	8.2%	2.5%	3.1%
	846	603	375
Horse	86 kg	267 kg	400 kg
	6.2%	2%	2.4%
	80	69	45
Donkey	20 kg	60 kg	80 kg
	4.1%	1%	2.3%
	11	9	6

East Caucasian Tur ***C. cylindricornis*** and Chamois ***Rupicapra rupicapra*** were wild potential prey that occurred in the home range. We used Tur and Chamois demographic data (Ponkova 1967, Magomedov ***et al.*** 2001) and minimum numbers calculated from densities (Ponkova 1967, Magomedov ***et al.*** 2001) and optimal home range sizes (Gavashelishvili 2004) within the home range to estimate monthly biomass of their carcasses. Minimum numbers were used because their numbers dramatically varied seasonally.

Statistical analyses were performed using SPSS v.11 for Windows (SPSS Inc., Chicago, IL). Means and standard deviations are reported unless otherwise stated.

Results

Productivity

Despite catching the bird at a time when we thought we might cause desertion, it returned to its nest immediately and ultimately succeeded in hatching and fledging a chick. In the year following capture (2003) the bird produced another fledgling from the same nest. In 2004 the bird occupied the same home range, but did not breed.

PTT temperature

Mean nighttime temperature of the PTT was 23±3˚C (range: 13–31˚C, n=209) was less variable (F=140.38 df=1, 948, P<0.001) and significantly greater (***t***= 16.261, df= 848.499, P<0.001) than mean daytime temperature (18±7˚C; range: -7–37˚C, n=741). Figure 2 shows variation in PTT temperatures for the duration of the study.

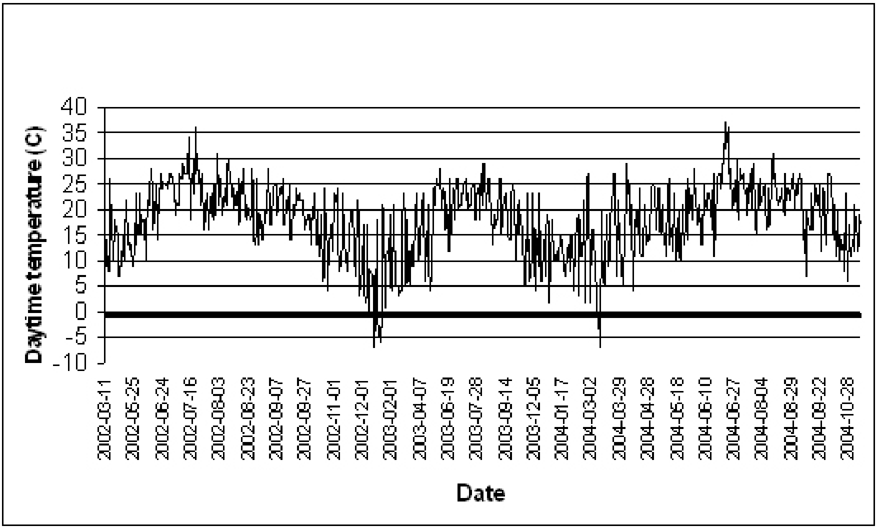

Figure 2. Daytime temperature variation of a PTT deployed on a Bearded Vulture in the Republic of Georgia.

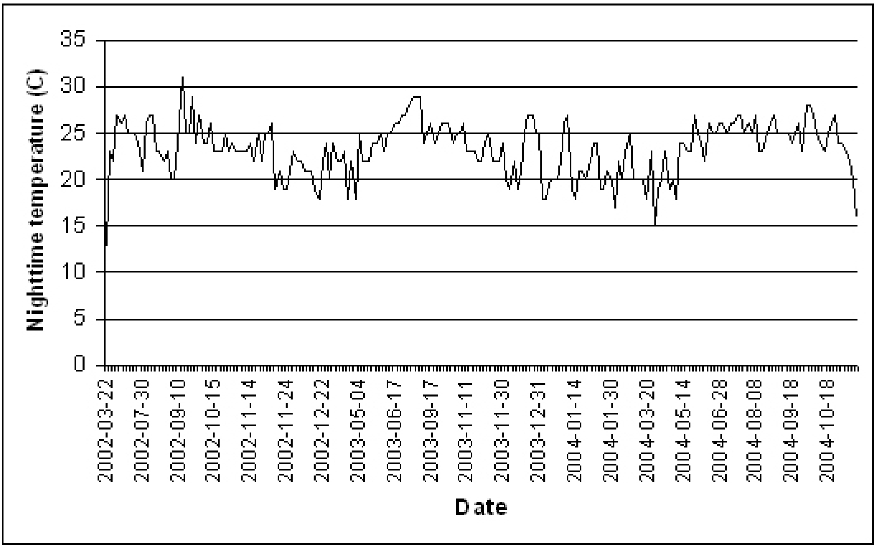

Figure 2. Nighttime temperature variation of a PTT deployed on a Bearded Vulture in the Republic of Georgia.

Argos locations

A total of 1323 locations were obtained (Table 2), 41.5% of which were useful in determining extent of ranging. Daytime locations (n=969) were about three times as numerous as nighttime locations (n=354). Mean distance from the nest to all LC-3, 2, 1, A locations was 9712.79±12780.88 m (range: 110.94-137829.97 m, n=552).

Table 2. Distribution of location classes of locations obtained from a single territorial Bearded Vulture.

LC	***N (%)***
3	25 (1.8)
2	74 (5.5)
1	156 (11.8)
A	297 (22.4)
0	346 (26.2)
B	425 (32.1)
Total	***1323***

Home range characteristics

Table 3 summarizes characteristics of the kernel home range. The nest of the radio-marked Bearded Vulture was 17650 m from the nearest neighbour, 1864 m from the nearest populated area and 663 m from the nearest road. The home range was at high elevation in rugged terrain, was sparsely populated and contained many streams. It was sparsely wooded and was a mosaic of pastureland and inaccessible mountainous areas. Cultivated fields were restricted to the immediate vicinities of populated areas. Livestock numbers increased dramatically in summer, when herds returned from distant lowland winter grounds. Chamois numbers also increased during the summer with the arrival of animals from lower wooded areas outside the home range. Tur numbers increased in winter as they descended from sub-nival and alpine areas to winter on south-facing slopes within the vulture's home range.

Table 3. Home range (95% fixed kernel) characteristics of a territorial female Bearded Bulture in the Republic of Georgia, 2002-2004.

Home range characteristics	
Planar area (km^2)	206
Surface area (km^2)	240
Elevation, m (mean+SD, range)	2586+368, 1806-3736
Nighttime temperature in July, °C (mean, range)	12, 5–15
Nighttime temperature in January, °C (mean, range)	-10, -60–0
Annual rainfall, mm (mean +SD, range)	1145.2+261.2, 800-1732
Hours of sunlight per year (mean+SD, range)	1903+11 .9, 1900-1998
Woodland (%)	5
Human population	700(winter) – 1060(summer)
Distance to roads, m (mean+SD, range)	1974+1444, 0-6273
Minimum monthly biomass of livestock (kg)	1128
Minimum monthly biomass of Tur (kg)	47
Minimum monthly biomass of Chamois (kg)	3

Discussion

Because the data are from a single individual, care should be taken when generalizing from them. However, because Bearded Vulture ranging using telemetry has not been described in the peer-reviewed literature before, the data are potentially important. More than 60 vultures have been tracked using radio telemetry in the Pyrenees (R. Heredia pers. comm.), but these data have not been published. Reintroduced bearded vultures are being tracked, and some information is available on the internet (Hegglin pers. comm.; http://www.wild.unizh.ch/bg/sat/s_frame.php?bi=0&bg=0&ya=0&la=e&th=sat&st=1&su=0).

It appears that the vulture that we trapped was not sufficiently disturbed by capture or carrying a transmitter to suffer measurable reproductive effects during the course of our study. We were surprised when, after capture, it immediately returned to the nest, incubated the eggs, and ultimately reared a chick. A general rule of thumb when working with raptors is that the larger, longer-lived species are more sensitive to disturbance, particularly when they do not have nestlings. The logic behind this "rule" is that K-selected species will abandon nests when disturbed because it is an evolutionary good bet that they will breed again if they survive. That we caught the bird about 2 km away from the nest may have influenced the response by the vulture, in that it may not have associated the disturbance with the nest site, and was not deterred from returning to it. Perhaps less surprising was that the vulture bred in the year after being captured.

We expected the temperature of the PTT to drop considerably at night, especially because it was mounted as a harness, and we expected the greatest drops to be in winter. However, regardless of season, PTT temperature was significantly higher and less variable at night than day. Bearded Vultures nest in large cavities, and their nighttime roosts are in protected sites including nesting caves. Cavity roosting has been shown to reduce body heat loss in birds (e.g. McCafferty ***et al.*** 2001). We think that the three fold difference between daytime and nighttime location rates by the system is linked to nighttime roosting in caves and on overhung ledges that have poor satellite visibility. A likely explanation of the temperature fluctuations that we observed is that wind chill during daytime caused cooling while roost sites protected against this. In addition, we believe that the greater variation in daytime temperatures is likely due to periods of solar heating in relatively protected places and wind cooling, especially during soaring.

These characteristics of temperature sensor data for Bearded Vultures can act as a surrogate for the activity sensor that is standard in the Northstar PTT that we used (and in other brands of PTTs), and can be used to confirm that a PTT is still attached to a living bird. This could be useful because in some cases the activity sensor can be activated even though the vulture was not alive (e.g. on a dead animal, but being blown by the wind or having been lost from a live animal and hanging from the nest or a tree), and because if one uses the temperature data as a surrogate for the activity sensor, free space may become available for the inclusion of another sensor, if desired.

Our results show the adult Bearded Vulture we tracked to be a year round resident, as elsewhere (Cramp & Simmons 1980, Brown 1988, Heredia 1991). The size of the range was larger than the 160 km2 reported for a pair in the Pyrenees (Suetens & van Groenendael 1974), though potential location errors by the Argos system could easily explain this difference (Britten ***et al.*** 1999, Vincent ***et al.*** 2002), as could the inability of the researchers in the Pyrenees to detect Bearded Vultures when they were at the farthest extent of their range. Despite having a body size similar to that of the Eurasian Griffon ***Gyps fulvus***, the home range was much smaller (only 5% the size) than that of a griffon tracked via satellite in the same area for a similar amount of time (A. Gavashelishvili unpubl. data).

A large amount of carrion was estimated to occur each month within the home range. However, not all of the dead livestock is available to the Bearded Vultures because some carcasses are near populated areas where vultures could be deterred from landing. In addition, only a portion of the carrion that is available is useful to the Bearded Vulture because of the bone-specialized feeding habits of the adults. Carcasses of Tur alone, which nearly always occur away from regular human disturbance, potentially provide at least 564 kg per year. This is more than the 300-350 kg of meat and bones needed by breeding pairs of Bearded Vultures (Hiraldo ***et al.*** 1979, Brown 1988). Other species that could compete for carcasses were Domestic Dogs ***Canis familiaris***, which are restricted to populated areas, Foxes ***Vulpes vulpes*** and Eurasian Griffons. However, because of the Bearded Vulture's specialization on bones, competition from these species was for the most part not direct.

Since 1986 more than 120 Bearded Vultures have been re-introduced in the Alps. For the most part, their movements, survival and recruitment have been monitored through a system of feather bleaching (Frey ***et al.*** 2002). There has been reluctance, based on adopting a cautionary principal, to use any type of transmitter, especially one that is harness-mounted, for tracking released Bearded Vultures, and this reluctance has been reinforced by reports and video of vultures fitted with radios with a dangling harness strap in the Pyrenees, and negative experiences with captive vultures (H. Frey pers. comm.). However, because details of vulture movements may be critical to post-reintroduction conservation, enhancing the amount and quality of information on vulture survival and dispersal is important. As a result, in 2002 transmitter attachment trials were undertaken on captive Bearded Vultures (Hegglin ***et al.*** 2002) that showed no significant change in behaviour due to the tagging, even with harnesses. Since 2004 two released vultures that were tagged, one with a tail and one with a pelvis mounted PTT, in Switzerland have survived (D. Hegglin pers. comm.). Our success in tracking a Bearded Vulture with a backpacked PTT, along with the findings of Hegglin ***et al.*** (2002), and new harness designs (Rappole & Tipton 1991, R. Bögel & D. Hegglin pers. comm.) should contribute to the discussion of the feasibility of radio tracking and using harnesses on Bearded Vultures.

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