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Brief report

Ranging behaviour of a juvenile Bearded Vulture (*Gypaetus barbatus meridionalis*) in South Africa revealed by GPS satellite telemetry

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A second-year Bearded Vulture was equipped with a GPS transmitter and located on average 10 times a day from 6 September 2007 to 22 June 2008. During this period, the individual ranged in an area of ca. 38,500 km^2 across the mountainous regions of Lesotho and the north-eastern Cape province of South Africa, thus covering on average 66 km/day, mainly in areas covered by scrubland and herbaceous vegetation. Three different activity areas with a temporal overlap of locations within them were observed. The ranging behaviour could be explained by two non-exclusive alternative hypotheses: food searching and territory exploration. The information provided here may serve to identify potential threats for the species, such as poisoning, collision with power lines, food scarcity and persecution.

1. Introduction

The nominate subspecies of Bearded Vulture (*Gypaetus barbatus barbatus*) is globally distributed from the mountain ranges of Europe and Asia to Northern Africa. In Eastern and Southern Africa the subspecies *meridionalis* is distributed into two main isolated subpopulations: one in Ethiopia, Kenya, Uganda and Tanzania, and another in Southern Africa (Mundy *et al*. 1992). Although the Bearded Vulture is not globally threatened (BirdLife International 2009), the South African subpopulation has drastically declined during the last decades, with less than 200 pairs surviving in this region (Piper 2006); therefore, the species has been listed as Endangered in South Africa (Anderson 2000). The species has also experienced a reduction in range, mainly attributed to the loss of natural ungulates and the intensification of livestock farming, which have led to a reduction in the food supply (Piper 2006) or poisoning (Brown 1991, 1997a). Additional factors include collection for traditional medicine (Mundy *et al*. 1992), disturbance at nests and collisions with power lines (Brown 1991).

Although most ecological aspects of the South

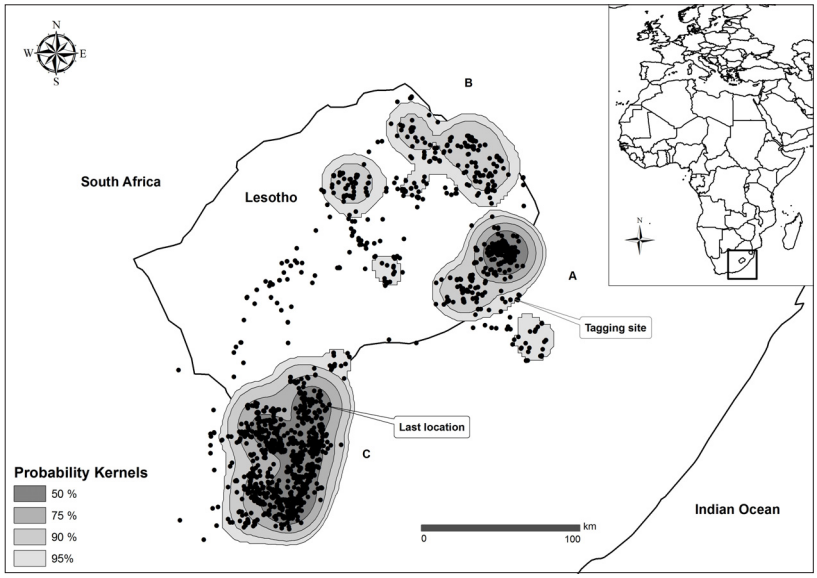

Fig. 1. Probability kernel analyses for the movements of a juvenile Bearded Vulture in Lesotho and South Africa. The upper-right map indicates the location of the study area. Dots indicate GPS locations recorded during the study. For area codes A–C and details, see text.

African Bearded Vulture subspecies are well known (e.g., Brown 1977, 1991, 1992, 1997b; see Piper 2006 for a review) there is a lack of scientific knowledge about ranging behaviour of juvenile, floater and adult birds. Here we describe the ranging behaviour of a juvenile bird in South Africa which, as far as we know, to date is the first description of the movements of Bearded Vultures tracked by satellite telemetry.

2. Material and methods

A second-year female Bearded Vulture (*Gypaetus barbatus*) was captured at Waterford Farm, near the uKhahlamba Drakensberg National Park (South Africa). The bird was trapped on 6 September 2007 using a noose carpet with carcasses used as bait in a "vulture restaurant" (29°52'16.79" S, 29°19'25.79" E). Sex was determined using molecular methods (Fridolfsson & Ellegren 1999), and the individual was tagged using a Microwave Telemetry's ARGOS/GPS 70-gram solar-powered PTT-100 that was affixed using a pelvic harness reinforced with silicone to avoid problems associated with bird growth (e.g., Kenward 2001). The transmitter was programmed to record a GPS position once an hour from 06:00 to 22:00 UTC every day throughout the year, and to transmit the recorded data to the satellites of Argos System every three days. The transmitter stopped sending information on 22 June 2008 and was never recovered. All data were retrieved and managed using Satellite Tracking and Analysis Tool (Coyne & Godley 2005; available at MoveBank, http://www.movebank.org/).

We estimated the home-range of the bird by means of a kernel approach, including all GPS locations (Kenward 2001), using Animal Movement Extension (Hooge & Eichenlaub 1997) for ArcView 3.2. We calculated the 50%, 75%, 90% and 95% fixed kernels. Following Hooge and Eichenlaub (1997), we used the least squares cross validation (LSCV) procedure to calculate the smoothing parameter (H). Kernels were calculated using the geographic coordinates and hence, shapes generated with ArcView 3.2 were transformed to an Equal-Area Cylindrical projection using the "Projector!" extension for ArcView 3.2 to estimate real areas of home-ranges. Additionally, we calculated the Minimum Convex Polygon (MCP) encompassing all the locations obtained for the bird, using the same projection conversion as for the kernel analyses (see above).

We also calculated the daily distances covered by the individual as the sum of distances covered between consecutive locations in a given day. For this purpose, we only calculated displacements between consecutive locations that were separated by one hour. We excluded displacements recorded

Table 1. Ranging schedules of a juvenile Bearded Vulture tracked by GPS satellite telemetry in South Africa and Lesotho. For area codes A–C, see text.

Area	Initial date	Final date	Time (days)	Daily distance (km)	Cumulative travelled distance (km)
A	07/09/2007	12/09/2007	5	47.86	47.86
B	12/09/2007	24/09/2007	12	115.74	810.15
A	24/09/2007	11/11/2007	48	46.65	979.56
B	11/11/2007	09/12/2007	28	67.26	672.60
C	10/12/2007	12/05/2008	154	64.22	4174.27
B	12/05/2008	16/05/2008	4	135.09	270.17
A	16/05/2008	24/05/2008	8	103.29	723.03
C	24/05/2008	22/06/2008	29	22.82	114.10

over one-hour time periods (which happened if the transmitter did not function properly) from the data to avoid underestimating daily movements (Limiñana *et al*. 2007). In addition, we only used days with at least $N + 1$ locations for computing, where N is the median number of locations separated by one hour obtained for each day (here, $N = 9$). Overall, we used data from a total of 118 days, with a range of 10–16 locations per day, to calculate the mean daily distance covered by the juvenile vulture.

We used the Global Land-cover Map 2000 (GLC 2000; http://bioval.jrc.ec.europa.eu/products/glc2000/glc2000.php) to characterize the different areas in terms of land-use coverage, and explored whether the juvenile Bearded Vulture spent more time in certain habitats than expected by chance. We generated 3000 randomly distributed points within the MCP encompassing all GPS locations and assigned a land-use class both for these random points and for the observed locations. To find out whether the bird preferred particular habitat types, we compared the frequency of random points in each land-use type by means of contingency tables and the G test for maximum likelihood (Sokal & Rohlf 1994, Soutullo *et al*. 2008b). The critical alpha level was set at $p < 0.05$.

3. Results

During 6 September 2007–22 June 2008, a total of 2,975 GPS locations (with a nominal error of 18 metres) were received. The tagged bird moved in an area of ca. 38,500 km^2 as estimated by the MCP, with most locations obtained in Lesotho and the rest in South Africa. Estimated fixed kernel areas were 3,196 km^2, 5,859 km^2, 11,221 km^2 and 16,719 km^2 (for 50%, 75%, 90% and 95% kernels, respectively). Three main activity areas of the juvenile were identified (Fig. 1). The first area (area A; MCP surface = 3,362 km^2) was in the mountainous areas at the eastern border of Lesotho with South Africa (KwaZulu Natal province), i.e., the Drakensberg National Park; the second area (B; 8,687 km^2) encompassed the central and north-eastern mountains of Lesotho; and the third area (C; 10,324 km^2) encompassed the southern border of Lesotho and the north-eastern part of the Eastern Cape province, South Africa. Interestingly, locations within the zones overlapped temporally, with the bird moving among these areas in short time periods (ca. 2 weeks; Table 1). In relation to daily ranging behaviour, the bird covered a mean distance of 66.03 (± 42.44 SD) km/day, with distances ranging from 0.11 to 221.47 km/day. The bird ranged extensively across the mountainous regions of Lesotho and the North-eastern Cape province of South Africa. It spent 183 days in the southern area (area C) and moved consecutively from the area A (61 days) to the area B (44 days) and then to C, but with several returns to the other areas (Table 1).

In terms of habitat types, the bird was mainly located at scrubland areas (80.23% of the locations), followed by herbaceous areas (10.12% of the locations) and other types of habitat, such as deciduous open forests (7.80% of the locations), cultivated and man-managed areas (1.65%) and deciduous closed forests (0.20% of the locations).

The observed frequencies differed from those expected from a random sampling of the main habitats occurring in the region ($G = 321.37$, df = 5, $p < 0.001$), the bird thus showing a preference for open habitats instead of forested and cultivated areas.

The bird was found exhausted (possibly by poisoning) near a shepherds' homestead in the end of May 2008. According to the shepherds' testimony, their dogs killed the bird and they buried the animal after removing the transmitter. The transmitter was smashed by local people who thought it was a witchcraft artifact (S. Krueger, pers. comm.).

4. Discussion

The ranging movements and home ranges of juveniles and adults are poorly understood over the whole distribution range of the Bearded Vulture. Breeding adults are resident throughout the breeding season that may include almost any time of year (Piper 2006). Home ranges for marked individuals in the South African population ranged between 75 and 80 km in diameter (Brown 1997a), but daily movements longer than 80 km have been reported, especially for juveniles (Mundy *et al*. 1992). For example, a radio-tracked juvenile Bearded Vulture had a progressively increasing home range during the post-dependency period (Brown 1990). During the first months after fledging the bird accompanied its parents during foraging trips. The parents fed the juvenile for at least five months. Juveniles abandon their natal territory during the first month of their parents' next breeding attempt (Brown 1990). The areas reported by Brown (1990) were considerably smaller (78 km^2 at 3–4 months, and increasing up to 168 km^2 during the 4–6 months, after fledging) than those reported here, but the bird followed by Brown (1990) was young and not fully independent of its parents. Also the method employed to estimate ranging behaviour differ (radio telemetry vs. satellite telemetry), the former probably being more conservative.

The ranging behaviour shown by the GPS tagged juvenile Bearded Vulture may be a response to food searching, territory exploration, searching for a partner or interactions with conspecifics. Searching for food may explain why the bird spent considerable time in open areas where food is generally more visible or accessible for this species than in forested areas, and may explain why it returned to areas it had previously explored. In fact, a spatially unpredictable or highly dispersed food resource can be a major determinant of scavenger ranging behaviour in some species, especially for juvenile non-territorial birds (Donázar 1993). Apart from food, interactions between conspecifics may cause birds to wander widely in response to aggression or in search of partners (e.g., for setting up reproductive trios; Bertran & Margalida 2002). Such behaviour may occur in spatially structured populations for which the acquisition of information about the quality of territories is important in order to determine future breeding performance (Soutullo *et al*. 2008a, 2008b). The establishment of a good territory would confer an advantage in the short and medium-long term (Urios *et al*. 2007; Soutullo *et al*. 2008a, 2008b; Cadahía *et al*. 2009). Although none of these effects can be tested rigorously with just one individual, the extent and limits of the scale of ranging is nevertheless interesting and informative.

Despite the low sample size associated with the satellite tracking technology, the advantage of this method is that it allows observers to obtain spatially explicit information about animal movements and their habitat use, both of which are fundamental for conservation. Therefore, it is crucial to identify the scale of movement and habitat use by birds and if possible to locate potential dispersal or potential foraging (concentrations of data and distances between them) areas of juvenile Bearded Vultures. These data help to identify key locations and potential threats for this species, such as those related with poisoning, collisions with power lines, food scarcity and persecution (Piper 2006). The current satellite-tracking programs that are being carried on in South African and other Bearded Vulture populations will certainly provide complementary information useful for appropriate management measures aimed at improving the conservation status of this endangered species.

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Nuoren partakorppikotkan käyttäytyminen satelliittiseurannassa

Toista vuottaan elävälle partakorppikotkalle (*Gypaetus barbatus*) asennettiin satelliittilähetin. Yksilö paikannettiin keskimäärin kymmenen kertaa vuorokaudessa 6.9.2007–22.6.2008, jolloin se eli 38 500 km^2 alueella Lesothon ja Etelä-Afrikan Capen provinssin seuduilla. Päiväkohtaisesti yksilö siirtyi keskimäärin 66 km ja näytti suosivan pensaikkojen ja ruohovartisten kasvien ympäristöjä. Yksilö vietti aikaansa kolmella selvästi erottuvalla, ajallisesti päällekkäisellä alueella. Käyttäytymistä voi selittää ravinnon ja/tai reviirin etsintä. Tulokset auttavat määrittelemään lajiin kohdistuvia uhkia, joihin tunnetusti kuuluvat myrkytykset, voimajohtoihin törmäykset, ravinnon niukkuus ja vainoaminen.

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