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<http://www.italian-journal-of-mammalogy.it/article/view/9954/pdf>

doi:10.4404/hystrix-25.1-9954

Short Note

## Fatal long distance roaming of a male bear highlights survival threats to dispersing bears in the Apennines, central Italy

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Apennine brown bear  
connectivity  
dispersal  
non-invasive genetics  
survey  
*Ursus arctos marsicanus*

**Article history:**

Received: 14 March 2014

Accepted: 14 April 2014

**Acknowledgements**

The SNP Authority, the Marche Region, the Natural Reserve of Montagna di Torricchio, the National Forestry Service (Visso, MC) all funded and supported the bear monitoring in the SNP. The Smilax association, N. Felicetti, and F. Franconi helped with field work. Many farmers and bee keepers contacted us to report the presence of bears. David Paetkau (Wildlife Genetics International) analyzed the tissue sample from the dead bear in the SVRP and provided correction factors to match bear genotypes previously scored by ISPRA. Leonardo Gentile, PNALM Veterinary Service, provided details of the capture and subsequent death of bear G70 in the SVRP.

**Abstract**

From September 2006 through May 2010, we repeatedly detected an adult male bear (G70) through non-invasive sampling in the Sibillini National Park (SNP; central Apennines, Italy), at the northernmost periphery of the reported Apennine bear range. Notwithstanding sustained sampling effort, we failed to detect bear G70 in SNP after May 2010, but in autumn 2010 it was twice detected, through non-invasive sampling, in the Duchessa Nature Reserve (76 km south of the SNP), revealing its southward travel across the central Apennines. More than one year later (16 January 2012), a male bear was live-captured in the Sirente-Velino Regional Park showing clinical symptoms of Aujeszki's disease. The bear died overnight, and genotyping revealed it to be bear G70. Although the causes of death were not clearly determined, poisoning, shooting and vehicle accident were ruled out, suggesting more subtle mortality factors (e.g., diseases) were responsible. The long distance movements and the fate of this adult male bear indicate that, even though protected and suitable areas are connected across the Apennines to some degree, the expected expansion of the Apennine bear range from the core distribution might be suffering from undisclosed anthropogenic risks of mortality in the peripheral portions of the range.

Isolated from other bear populations in the north for 400–700 years (Randi et al., 1994; Lorenzini et al., 2004), the Apennine brown bear (*Ursus arctos marsicanus*) currently survives as a relict and isolated population whose core range comprises the National Park of Abruzzo, Lazio and Molise (PNALM) and adjacent areas. The conservation chances of the small Apennine bear population are strongly dependent on the successful expansion of the source population beyond the PNALM borders and across a larger area in the central Apennines (Ciucci and Boitani, 2008; Anonymous, 2011). This, in turn, is a function of the dispersal pressure from the core population, the functional connectivity of suitable habitat across the Apennines, and the survival of bear propagules in the peripheral portions of the range (Ciucci and Boitani, 2008; Falcucci et al., 2009). In addition to illegal human-caused mortality, human activity in the Apennine ecosystems (i.e., livestock grazing, timber harvesting, development, vehicle traffic, hunting, tourism, etc.) may affect the survival of dispersing bears, potentially offsetting any attempt to permanently recolonize former portions of their historical range (Anonymous, 2011). Indeed, erratic bears have been recorded outside the core range over the past few decades (Boscagli et al., 1995; Boscagli, 1999), but no significant expansion of the range has been observed, notwithstanding considerable conservation efforts, a rich network of protected areas, and suitable habitat across the Apennines (Posillico et al., 2004; Falcucci et al., 2008, 2009). No evidence

of reproduction in the peripheral portions of the range has been recently reported (Boscagli, 1999; Ciucci and Boitani, 2008), and no data are available on the individual fate of dispersing bears.

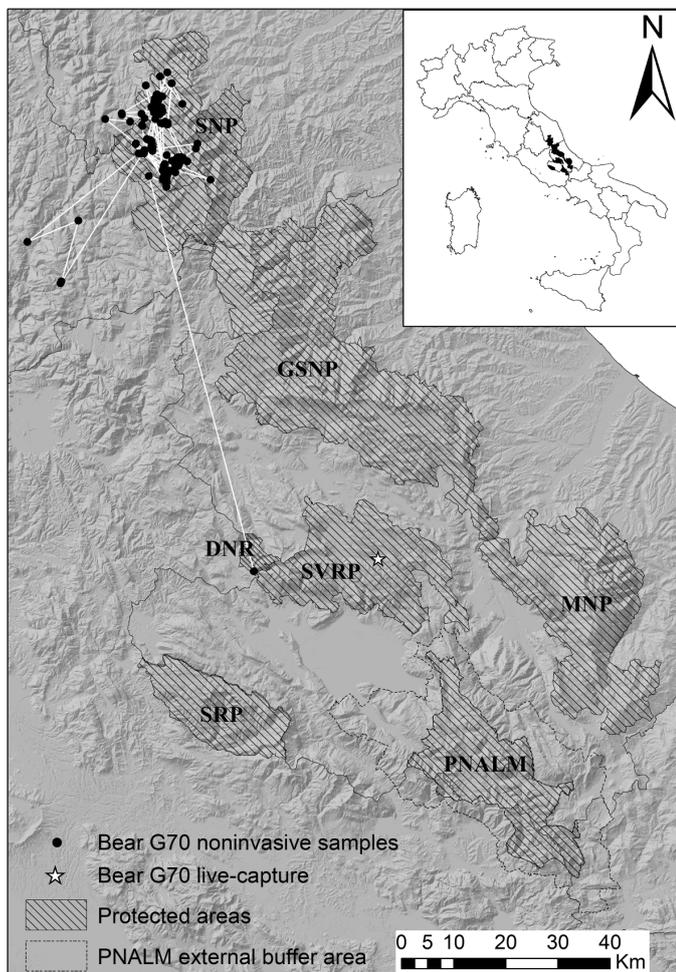
The recent development of non-invasive detection methods (Long et al., 2008) and renewed efforts for the conservation of the Apennine brown bear (Ciucci and Boitani, 2008; Anonymous, 2011), has led to more structured and coordinated initiatives to record bear presence in the peripheral portions of the Apennine bear range (e.g., ARP 2008; Forconi and Dell'Orso 2008). In particular, the standardized collection of bear signs, coupled with the application of non-invasive genetic sampling has allowed the detection and intensive monitoring of individual bears in Sibillini National Park (SNP; 700 km<sup>2</sup>) and in the Duchessa Nature Reserve (DNR; 35 km<sup>2</sup>), both located in the peripheral portion of the bear range (Fig. 1).

Since 2006, bear presence has been detected in SNP using hair traps (Woods et al., 1999) and remote IR cameras (Bushnell 119901, Scout Guard SG550, Reconyx RC60, Keep Guard KG560, Cellular KG 580M). Following up on damage reports and intensive search for bear signs, we opportunistically placed camera traps in areas of recent bear presence. Genetic analyses of hair and faecal (DNR only) samples were conducted in the Conservation Genetics Laboratory of ISPRA. Individual multilocus genotypes were obtained using a panel of 11 microsatellites, plus the Amelogenin AMG gene for sex identification, following procedures detailed elsewhere (Gervasi et al., 2010).

From September 2006 through May 2010, we collected 70 hair samples (51 in hair traps, 8 on barbed-wire fences, 7 at damaged bee-

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**Figure 1** – Location of the study area in central Italy (inset), and localities where bear G70 was detected in Sibillini National Park (SNP; October 2006 – May 2010) and Duchessa Regional Reserve (DNR; October 2010). In January 2012, bear G70 was captured in Sirente-Velino Regional Park (SVRP) showing clinical symptoms of Aujeszki's disease, and died overnight. Sampling locations are connected chronologically. However, connecting lines do not represent the actual travel routes used by bear G70. Other protected areas noted on the map are: Gran Sasso-Laga National Park (GSNP); Majella-Morrone National Park, Abruzzo Lazio and Molise National Park (PNALM), Simbruini Regional Park.

hives, and 4 along bear trails) in the SNP, and obtained photos from 12 bear visits and video clips from 5 visits, all depicting a single adult bear (Tab. 1). In addition, during the same period we opportunistically collected 128 bear scats, reconstructed 22 km of trajectories in the snow of a single adult bear, and verified bear damage to 6 apple trees, 7 beehives, and 1 sheep.

We used 27 bear hair samples for genetic analyses, 20 of which were successively scored at all loci. All scored hair samples, collected from 2006 to 2009, were consistent with a single genotype belonging to one bear, G70, which had not previously been detected. As we had no evidence from any survey method of more than one bear frequenting the SNP during the sampling period, we conservatively assumed all other bear signs belonged to bear G70, although we could not definitively confirm this. From 2006 to 2010, this bear moved across an area of 243 km<sup>2</sup> in SNP (Fig. 1), and also explored an area 18–27 km southwest from the SNP (Valnerina) where in 2007 we detected signs of bear presence for about 3 months (June–August). The northernmost detected location of G70 in SNP was 120 km from the northern border of the PNALM outer buffer area (Fig. 1). Despite our comparatively high sampling effort throughout the area previously frequented by this bear (Tab. 1), we found no further evidence of bear presence in the SNP after 2 May 2010. However, one faecal and one hair sample matching bear G70's genotype at all markers were collected in the DNR on 25 and 28 October 2010, respectively, 76 km from the closest detected location of G70 in SNP. No close genotype similarities (i.e., 1 or 2 MM-pairs; Paetkau 2003) were detected between bear G70 and the other 9 bears

**Table 1** – Sampling effort and detection of bear presence in Sibillini National Park (October 2006 – December 2010) by hair trap and remote camera (other signs of bear presence, e.g., scats, tracks, and verified damage, are not noted). All genotyped hair samples (n=22) belonged to a single bear (G70). Traps were placed in areas of recent bear presence and were baited with apples or rancid fish oil to enhance trap attractiveness.

Trap type	Year	No. trap sites <sup>1</sup>	Trap-nights	No. bear samples <sup>2</sup> or detections <sup>3</sup>
Hair traps	2006	12	125	31 (2)
	2007	22	1527	11 (5)
	2008	7	1099	9 (9)
	2009	7	563	0 (3)
	2010 <sup>4</sup>	1	24	–
	2010 <sup>5</sup>	12	885	–
Remote cameras	2006	1	53	4
	2007	4	525	11
	2008	0	–	–
	2009	5	593	3
	2010 <sup>4</sup>	5	495	1
	2010 <sup>5</sup>	8	912	–

<sup>1</sup> Traps were not activated simultaneously

<sup>2</sup> The number of hair samples opportunistically collected by other means are noted in parentheses

<sup>3</sup> Number of independent (i.e., >30 min) bear visits

<sup>4</sup> January – May

<sup>5</sup> June – December

non-invasively detected in the central western portion of the peripheral range from 2006 to 2010, supporting the notion that bear G70 travelled from SNP to DNR between spring and autumn 2010. Bear G70 was never detected again in any subsequent surveillance sampling in DNR or SNP. However, on 16 January 2012 an adult male bear (ca. 8–10 years of age based on tooth wear) was captured in the Sirente-Velino Regional Park (SVRP) showing clinical symptoms of Aujeszki's disease (Zanin et al., 1997): the bear continuously scratched its head and neck with the fore paws, was unresponsive to humans, and circled around with uncoordinated movements (L. Gentile, *pers. comm.*). Following capture, the bear died overnight. Aujeszki's virus was not positively isolated and the ultimate causes of mortality remained unclear, however shooting, vehicle accident and poisoning by most common toxic compounds were all ruled out (P. Badagliacca, *pers. comm.*). The bear, subsequently revealed to be bear G70 through multilocus genotyping, was live-captured in the SVRP, 24 km away from, and more than 1 year after, its last known location in the DNR.

Bear G70's locations from 2006 to 2010 correspond to the northernmost area of the peripheral range recently confirmed for Apennine bears (Bologna and Vigna Taglianti, 1992; Carpaneto and Boitani, 2003). Although we do not know where bear G70 originally dispersed from, reproduction for Apennine bears is currently confined to the core range (Ciucci and Boitani, 2008). Therefore, it is likely that bear G70 dispersed northward from its natal range to reach the SNP in 2006 and, using the same or another dispersal route, moved southward again in 2010, indicating that some male bears can travel successfully over long distances across the Apennines. Non-invasive methods have recently detected bears in the central Apennines in similar cases of dispersal, albeit over shorter distances, revealing that some male bears may travel from and return to the core range (Di Clemente et al., 2012). While a formal evaluation of the functional connectivity across the central Apennines is still lacking, the movement route of bear G70 (Fig. 1) indicates that the local network of protected areas is still interconnected to some degree, and that at least some dispersing male bears may be able to circumvent infrastructures and anthropogenic barriers (Falcucci et al., 2009).

Female Apennine bears are strongly philopatric (Zedrosser et al., 2007) and the apparent lack, or extreme rarity, of adult females outside the core range underlines that range expansion by female Apennine bears is more problematic than for males. Due to the tendency of females to settle in or close to their mothers' home ranges, range expansion by female bears may be further depressed in stable or declining populations (Swenson et al., 1998; Kojola and Heikkinen, 2006; Jerina and Adamic, 2008). Range expansion by females in the Apennine bear population may therefore require several years during which the demographic trends of the core population need to be consistently positive, a

condition that was unlikely met in past decades due to persistently high levels of mortality (Ciucci and Boitani, 2008). In any event, the current lack of female bears outside the core range undermines any tendency of male bears to expand the range of the population. It also provides a likely explanation of why bear G70 wandered over large areas in the SNP to eventually move south, toward the core range, at the onset of the 2010 reproductive season. Similar long-distance, directional, and mating-related movements of male bears of reproductive age have been reported for the peripheral and male-biased bear population in the Julian Alps (Krofel et al., 2010), and are thought to enhance mating opportunities and reproductive success for males living at the fringe of the range where no females are present (Zedrosser et al., 2007; Krofel et al., 2010).

Given his estimated age of 8–10 years when captured in 2012, G70 might have dispersed to the SNP in 2006 at an age when most male bears typically leave their natal range (Swenson et al., 1998; Zedrosser et al., 2007). Bear G70 then wandered in the SNP and adjacent areas for four years, probably denning in the same general area, and spent an additional 1.7 years likely within, or adjacent to, other protected areas (i.e., DNR or SVRP) closer to the core range to the south. G70's travel underlines the availability of suitable habitat outside the core range (Posillico et al., 2004; Falcucci et al., 2009) and the stepping-stone role that protected areas might play for bears dispersing across the Apennines. However, bear G70's eventual fate clearly indicates that these same protected areas, and the landscape matrix in between, may act as population sinks (Falcucci et al., 2009). However, it also indicates that connectivity across the landscape *per se* can not ensure the expansion and survival of dispersing bears if mortality risk is not be effectively mitigated in the first place. While causes of illegal and accidental bear mortality have been exhaustively illustrated (Boscagli, 1987, 1990, 1999; Posillico et al., 2002; Wilson and Castellucci, 2006), more subtle mortality factors are difficult to assess. Diseases hosted by domestic and wild animals, for example, have been recognized as a serious threat to bear conservation in the Apennines only recently (e.g., Fenati 2010; Fenati et al. 2012; Di Sabatino et al. 2014). Aujeszky's disease is caused by an alphaherpesvirus essentially hosted by domestic pigs and wild boars, the latter representing the main reservoir in the wild (Müller et al., 2000). Bears can be infected through ingestion of contaminated meat, and death occurs within 24 hours of the development of the first clinical symptoms (Zanin et al., 1997). Aujeszky's disease is widespread in wild boar populations in Italy and the pseudorabies virus has been recognized as among the top epidemiological threats to Apennine brown bears (Fenati, 2010). A high proportion of bear fatalities remain currently unresolved as to their proximal causes (Ciucci and Boitani, 2008) and it is likely that the effect of diseases on the Apennine bear population are currently underestimated and the necessary management actions neglected.

Monitoring Apennine bear dispersal outside the core range is of crucial importance to obtain empirical evidence of functional landscape connectivity and, most importantly, to assess the survival of dispersing bears in the light of diffuse ecological traps (Falcucci et al., 2009). It is, therefore, crucial that local, regional, and central administrations promote and maintain long-term, locally-intensive, and coordinated large-scale survey efforts using non-invasive sampling to achieve this aim. Satellite telemetry should be considered a priority, as it would give us better information about the travelling routes, reproductive behaviour and eventual fate of male bears in the peripheral portions of the range. Meanwhile, we stress that proactively addressing the risks of bear mortality at the periphery of the Apennine bear range is a fundamental action if we want dispersing bears, especially reproductive females, to survive and reproduce successfully in the future. ☞

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