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Brown bears in Central Italy: a 15-year study on bear occurrence

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Abstract
The Central Apennine brown bear population, that has been ascribed to the subspecies *Ursus arctos marsicanus* Altobello, 1921 and is endemic to Central Italy, actually survives as an isolated, small population potentially at high risk of extinction. The population of *U. a. marsicanus* is mostly located in Abruzzo, Lazio and Molise National Park (Central Apennines). However, the Central Apennine peripheral distribution area of this subspecies is less known and it is presumed that bear presence occurs at lower density. The purpose of this study is to provide a new contribution to the knowledge of bear presence in this peripheral area, in order to enable its protection in the Central Apennines. The monitoring of bear presence was carried out in Sirente Velino Natural Regional Park and surrounding areas (600 km^2) from January 2000 to December 2014. Monitoring was conducted by collecting data along opportunistic survey trails in areas where the presence of bears had been previously confirmed by direct observations. A total of 237 records of bear presence were collected during the study period. Distribution of historic bear data reported for the period 1900–1991 for the study area (n = 61) and present data are compared. Data show a continuous presence of bears in the study area during the last 15 years. The monitoring program has also provided evidence of the stable presence of wintering bears and a more or less continuous presence of breeding bears in the study area, although observations of females with cubs were not available every year. Results led us to speculate about a wider than previously expected stable presence of brown bears in the peripheral Apennine range. These peripheral areas of bear distribution, both inside and outside protected areas, are crucial for conservation and more effort must be made to estimate bear occurrence outside the core range.

Keywords: *Apennine brown bear, bear occurrence, conservation, peripheral distribution,* Ursus arctos marsicanus

Introduction

The Italian brown bear *Ursus arctos* population, once widely distributed throughout Italy, has declined during the last two centuries. At the beginning of 1900 there were two residual populations still present, i.e., in the north (Alps Mountains, more precisely in the region of Trentino and in the area of Tarvisio, the border region between Italy and Austria), and in the central southern part of the country, the Apennines (Boscagli 1999; Osti 1999). The Central Apennine brown bear population has been ascribed to the subspecies *U. a. marsicanus* Altobello, 1921, which is endemic to Central Italy (Randi et al. 1994; Vigna Taglianti 2003; Lorenzini et al. 2004; Loy et al. 2008).

The Apennine brown bear actually survives as an isolated, small population estimated at about 40–50 individuals (Ciucci et al. 2015), potentially at high risk of extinction (Swenson et al. 2000; Gervasi et al. 2008). Population demography is still poorly known, while a high mortality rate is widely reported (Wilson & Castellucci 2006; Ciucci & Boitani 2008; Gervasi et al. 2008; Falcucci et al. 2009).

During the past few decades, habitat suitability and landscape connectivity increased markedly in the Central Apennines, mainly due to the expansion of protected areas; thus, habitat availability does not

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seem to represent a limiting factor for brown bears (Ciucci & Boitani 2008; Falcucci et al. 2009). The current bear range along the Apennine Mountains covers a densely and permanently occupied area of about 1500–2500 km^2, as well as peripheral areas of roughly 10,000 km^2 of suitable habitat where bears are present but their current status is poorly known (Ciucci & Boitani 2008; Falcucci et al. 2009).

Here, we present the results of 15 years (January 2000–December 2014) of opportunistic monitoring of bear presence in Sirente Velino Natural Regional Park, a protected area considered to represent one of the marginal regions of the species distribution, with the primary aim of gathering information on bear occurrence in this peripheral area, in order to contribute to the knowledge of the species in the Central Apennines and to improve the protection of one of the smallest and most endangered brown bear populations in the world.

Materials and methods

Study area

The study area (Figure 1) extended for about 600 km^2 in the Central Apennines at a close distance (a few dozen km) to the bear core area range. It includes Sirente Velino Regional Natural Park (established in 1989 and which currently extends over 540 km^2) and covers the Natura 2000 site "Sirente Velino" (IT 7110130; 42°11′N, 13°28′E).

The altitude range is between 400 and 2500 m above sea level (asl). Topography comprises two major reliefs (Sirente and Velino mountains), with the highest peak rising 2486 m asl.; along mountain slopes, narrow glacial valleys and rocky karst canyons are also present. Wide karstic plains (covering about 12% of the study area) extend at middle elevations (about 1200 m asl.), whereas 25% of the study area is above 1500 m asl. In the northern part of the study area, the middle river valley of the Aterno River is present. During winter, snow cover generally remains from December to March above 1400 m asl. The main habitat types are grassland and pastures (38.5%), with an extensive presence of shrubs (mostly *Juniperus* spp., *Rosa* spp.) and forested landscapes (45.2%), the latter including mixed deciduous forests (23.7%), beech *Fagus sylvatica* forests (16.8%) and conifer afforestations (4.7%) of black pine *Pinus nigra*. Above the treeline, meadows with shrubs (mainly *Juniperus nana* and *Arctostaphylos uva-ursi*) and rock outcroppings are present. Rocky areas and screes occupy about 5.9% of the study area. Crops include ca. 8.8% cereals and fodder, mainly along the Aterno River valley, while 10% of croplands, including orchards (mostly almond trees), are abandoned today. Urban areas are limited (1.4%) and the small human settlements still present are largely abandoned: human density is relatively low (around 13 inhabitants/km^2), due to the high emigration that occurred last century. The density of paved roads is about 0.5 km/km^2 and tourism occurs seasonally, for the most part in those areas easily reachable by highway.

Methods

We performed data collection using the "sign survey method", which has been widely used to study bear populations at low densities (i.e., Kendall et al. 1992; Clevenger & Purroy 1996; Elgmork 1996; Karamanlidis et al. 2007). In particular, brown bear occurrence in the Central Apennines was previously recorded via sign survey or by bear data collected opportunistically (Zunino & Herrero 1972; Fabbri et al. 1983; Bologna & Vigna Taglianti 1992; Russo & Boscagli 1992; Boscagli et al. 1995; Posillico 1996). Although we recorded bear presence with different intensity throughout the study period, we are confident that the long duration of our study compensated for possible limitations of the heterogeneous data collection, as reported by other authors (e.g., Kendall et al. 1992; Clevenger & Purroy 1996). From 2000 to 2005, monitoring was carried out by both systematic sampling (i.e., covering fixed transects) and opportunistic surveys. Starting in 2006, bear monitoring was conducted by opportunistic surveys only, because of its greater efficiency in data collection in our study area. We performed opportunistic sampling along walking trials, recorded via global positioning system (GPS), in areas where and when it was most likely to detect bear signs indicating potential refuge sites, feeding areas, occasional livestock carrion and movement corridors.

In addition, we also collected bear presence data in the following ways: (1) from information collected by foresters of the Corpo Forestale dello Stato, L'Aquila Province rangers and biologists; (2) predation events on livestock; and (3) verified sightings by shepherds and other individuals (counting it as a bear sighting only when it was subsequently possible to verify it by the recording of tracks, scats or photographs; Elgmork 1996). Sightings and footprint sizes (Fernández-Gil 2013) allowed differentiating between the signs of the presence of lone adults and those of a female with cubs.

With the aim to evaluate the spatial and temporal distribution of the recorded data, the study area has been divided into five blocks or subareas, following main mountain edges: (1) south Sirente (sSir, ~103 km^2); (2) north Sirente (nSir, ~104 km^2); (3)

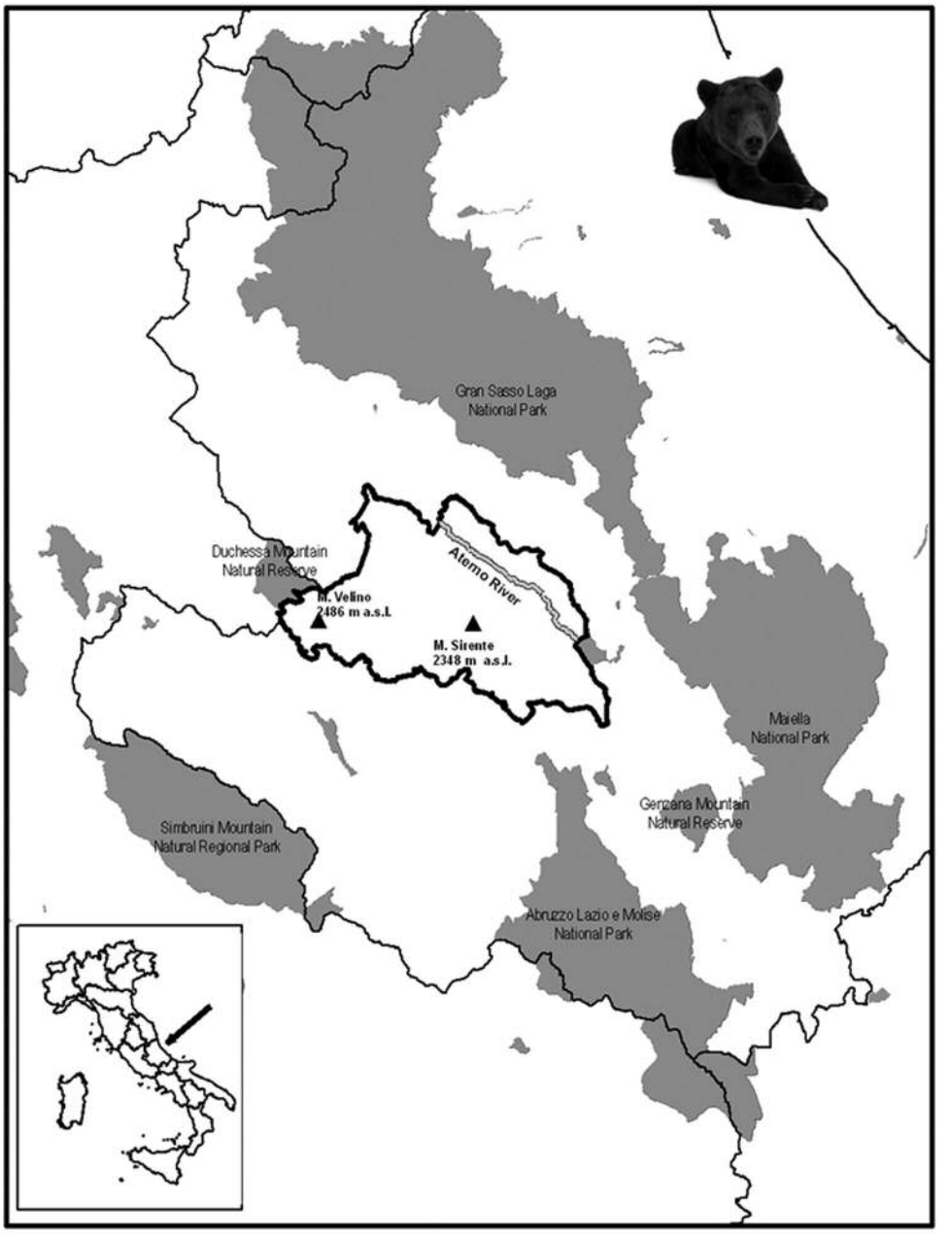

Figure 1. The study area (ZPS Sirente Velino-IT7110130) and neighboring protected areas. Picture copyright: Eric Isselee, Image ID: 7980363, http://www.123rf.com.

the valley of the Aterno River (AtrV, ~142 km^2); (4) south Velino (sVel; ~103 km^2); and (5) north Velino-Ocre (nVelO, ~77 km^2).

Results

A total of 237 records of bear presence were collected during the study period, and include: (1) 45.1% (n = 107) collected via opportunistic sampling; (2) 33.3% (n = 79) recorded by foresters, rangers and biologist; and (3) 21.6% (n = 51) representing verified observations obtained from shepherds and other individuals. Sampling effort consisted of 2128.7 km of opportunistic trails walked, corresponding to n = 107 data collected (Table I). During the study period, yearly presence of bears per block was detected as follows: 14 years in sSir, 12 years in nSir, 9 years in AtrV, 8 years in sVel and 6 years in nVelO.

Table I. Number of trails, km walked, number of brown bear data collected in the blocks by opportunistic sampling (n = 107) and the amount of data per 100 km.

Blocks	N of trails	km	N data	N/100 km
nSir	110	709.9	30	4.2
sSir	107	611.3	56	9.2
sVel	47	270.0	11	4.1
nVelO	47	333.5	3	0.9
AtrV	35	204.0	7	3.4

Scats represented 35.9% (n = 85) of the data collected, whereas 32.5% (n = 77) were sightings, 14.8% (n = 35) were tracks, 8.9% (n = 21) were attacks on livestock and 7.6% (n = 18) were related to other kinds of feeding signs, e.g., damage to beehives and fruit trees (Figure 2). In addition, in January 2012 we found an adult male (0.3%; ~8 years old) which died from disease.

During the study period there were two more dead bears in the surroundings of the study area: a ~5-year-old male that died in December 2008 in a bordering nature reserve (Duchessa Mountain), probably due to disease, and a ~3-year-old male that died in April 2013 from a traffic collision on a highway. In both cases the bears died 7–8 km west-northwest from the study area.

When comparing the bear distribution and amount of data (Figure 3) collected for the period 1900–1991 (n = 61; Boscagli et al. 1995), our survey allowed us to record 4 times more locations (n = 237) than were recorded in almost the whole past century.

When looking at the seasonal distribution of data (n = 218, including scats, sightings, tracks and attacks on livestock), tracks were more frequent/detectable in winter (n = 35, 6.9%), whereas scats (n = 85, 16.5%), sightings (n = 77, 17.9%) and attacks on livestock (n = 21, 6.4%) displayed higher proportions in summer (Figure 4). The distribution of data (n = 218) per block is shown in Figure 5.

Finally, of the 46.8% (n = 111) of bear records that consisted of sightings and tracks, 73.9% (n = 82) were lone individuals and 26.1% (n = 29) were females with cubs (corresponding to 12.2% of the total observations; Figure 6).

Discussion

Our data show a continuous presence of bears in the study area during the last 15 years, while the species has been recorded in this peripheral area since the beginning of the 1930s.

The distribution of bear presence in the study area mainly indicates: (1) a wider presence of the species nowadays than in the last century (Boscagli et al. 1995). This apparent increase of bear presence might be due to a real increase of bear numbers in the area, due to a higher level of protection of the area from 1990s. However, we cannot discard the possibility than an increasing search effort in the field may explain, at least partially, this result; and (2) that bear presence varies in the different blocks, suggesting that bears are not uniformly distributed within the study area and, consequently, the presence of zones of greatest conservation value within the massif.

Generally, brown bears in the Sirente Velino area are considered occasional (i.e., erratic individuals only; Zunino & Herrero 1972; Posillico & Lorenzini 2000; Posillico et al. 2004; Ciucci & Boitani 2008; Falcucci et al. 2009). Some authors have interpreted the presence of bears in this area as the result of population expansion or recolonization attempts (Fabbri et al. 1983; Posillico et al. 2004). However, other authors have suggested that the

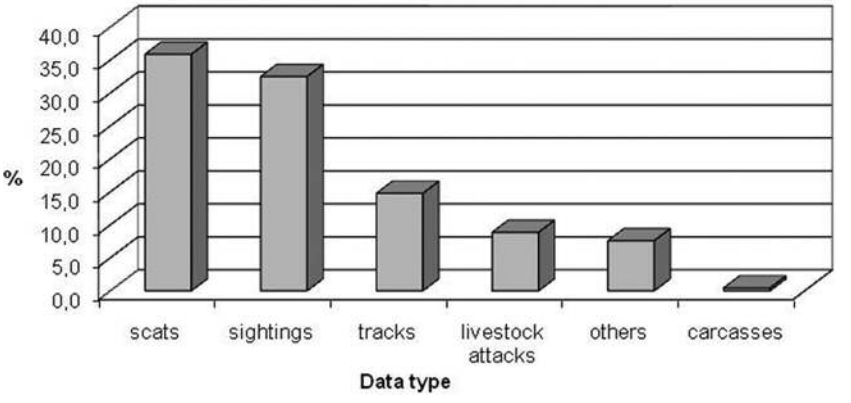

Figure 2. Frequencies of the different types of data (n = 237) recorded during the 2000–2014 period.

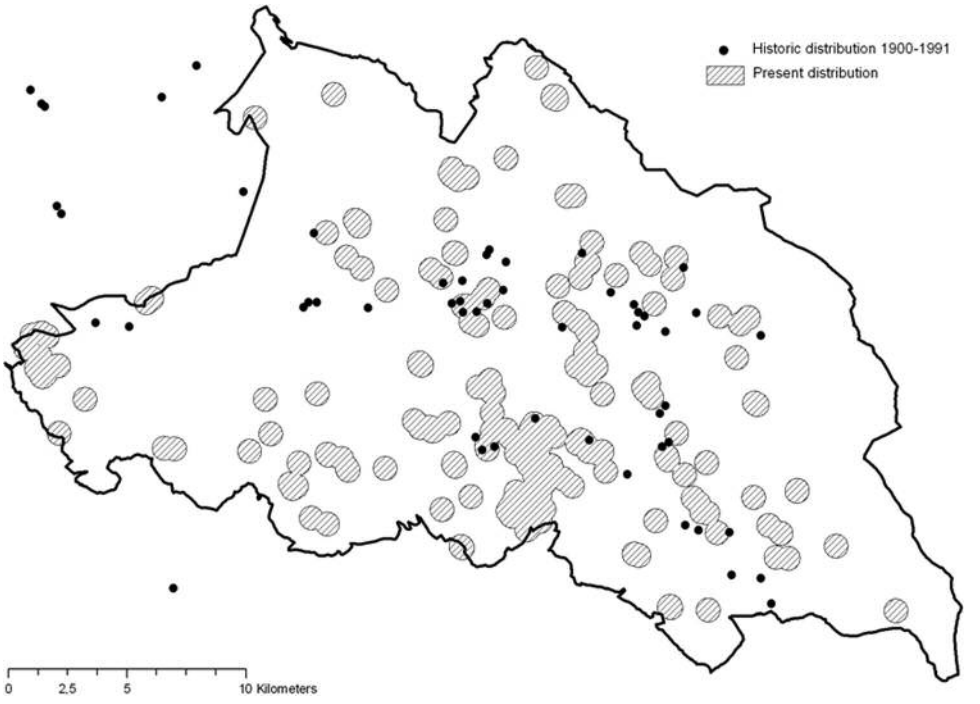

Figure 3. Comparison of the historic (1900–1991 period, n = 61; Boscagli et al. 1995) and current (n = 237) distribution of brown bear data the in study area and surroundings.

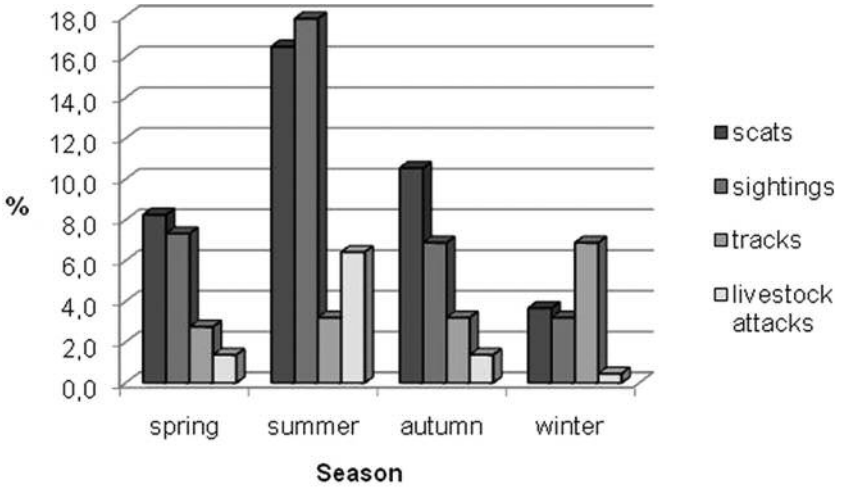

Figure 4. Seasonal distribution of the different types of data (n = 218).

presence of bears in our study area is predominantly related to resident individuals (Tassi 1989; Bologna & Vigna Taglianti 1992; Boscagli et al. 1995; Boscagli 1999). More recently, a male-biased dispersal of bears has been reported in the peripheral areas of the core distribution, which are considered to be highly connected to the main bear range in the Central Apennines (Carotenuto et al. 2014). In a study on the historical distribution of brown bears in the Apennine range, winter records were reported for the study area (Boscagli et al. 1995): our research has confirmed these previous observations, which suggest the presence of denning sites in the study area.

In the Central Apennines, the greatest number of reported occurrences have happened in autumn (Russo & Boscagli 1992; Posillico 1996), whereas in the present study most of the bear observations

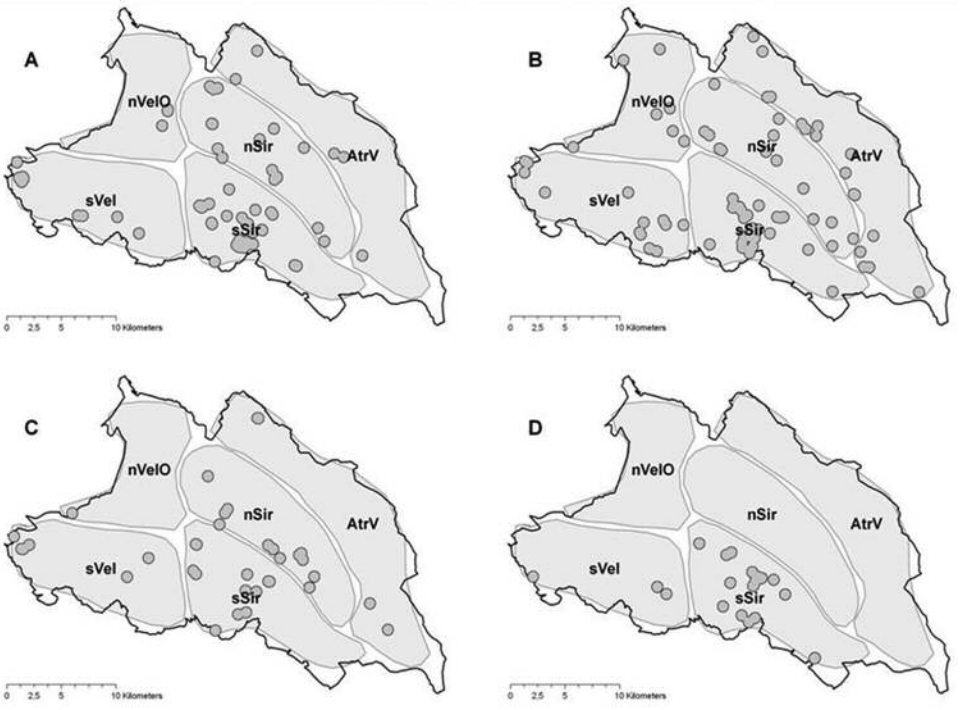

Figure 5. Distribution of data type collected (n = 218) in the study area blocks (see text for more details): (A) scats; (B) sightings; (C) tracks; and (D) livestock attacks. sSir: south Sirente; nSir: north Sirente; AtrV: Aterno River Valley; sVel: south Velino; nVel: north Velino.

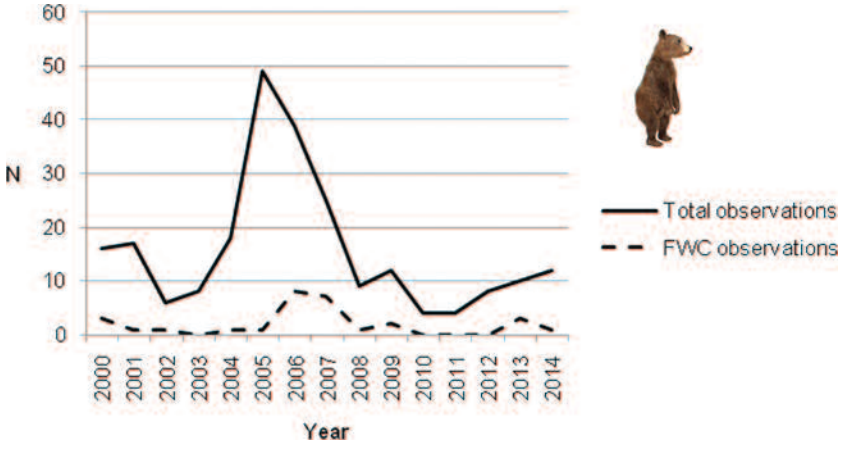

Figure 6. Number of total observations (n = 237) and observations of females with cubs (FWC, n = 29) per year. Picture copyright: Valentyna Chukhlyebova, Image ID: 39802292, http://www.123rf.com.

were recorded in summer. In this season, because of the lack of snow and the greater accessibility to mountain slopes, more people (both shepherds and tourists) share the landscape with bears and, consequently, the frequency of sightings is higher. In addition, during summer the opportunistic collection of data has led to the finding of bear scats near livestock carrion, which is widespread in the grassland during summertime. During our study, the presence of griffons *Gyps fulvus* aided in the discovery of carrion and, as a result, increased the detection of associated signs of bears. Thus, the greater number of scats collected in summer may largely be influenced by bear feeding on livestock carrion. Additionally, bear attacks on livestock are historically documented for the Apennine bear range and have also been reported for the study area (Zunino & Herrero 1972; Russo & Boscagli 1992; Boscagli et al. 1995; Kaczensky 1999; Zedrosser et al. 2001; Latini et al. 2005; Potena et al. 2005). Potena et al. (2005) reported a higher

frequency of bear attacks during summer for L'Aquila Province, which includes the extensive bear range of the Central Apennines.

Distribution of bear locations per blocks (Figure 5) shows that scats were mainly distributed (1) in main area of livestock grazing in summer, i.e., the southern slopes of Sirente and Velino mountains; and (2) in the richest feeding areas in the fall, located in the northern Sirente, where wild fruits (e.g. *Rosa* spp., and abandoned apple orchards) are abundant. On the other hand: (1) sightings were more widely distributed in summer; (2) tracks were generally scarce in the areas at lower altitudes in the Aterno River valley, mainly due to the scarce amount of snow; and (3) livestock attacks mainly occurred in southern blocks, which represent the main areas of livestock grazing.

Sightings of females with cubs were previously reported for the study area (Boscagli et al. 1995). In the present study, the data collected suggest a more or less continuous presence of females with cubs during the last 15 years, although observations were not available every year. The study area may also be used by bears that roam or disperse from the core area. For example, genetic evidence revealed that the ~8-year-old male we found dying was previously detected in the Sibillini Mountains, a national park located in the northernmost portion of the known bear distribution area (Forconi et al. 2014) and at ca. 85 km from the study area. Although during the study period we only encountered three dead bears, several authors have reported high mortality of bears in their Central Apennine range (Wilson & Castellucci 2006; Ciucci & Boitani 2008; Gervasi et al. 2008; Falcucci et al. 2009).

Conservation implications

Peripheral areas of bear distribution, both inside and outside protected areas, are crucial for species conservation and management. More precisely, the conservation and management of brown bears in the Sirente Velino, as well as in the other peripheral areas of bear presence in Abruzzo, should take into account the following aspects. First, peripheral areas should be continuously monitored over the years to increase our current knowledge of bear numbers in these areas, as well as to detect possible changes in bear numbers and distribution. Indeed, more effort should be made to estimate bear occurrence outside the core range. Second, bear attacks on livestock need particular attention because they may be critical for the conservation of individuals, and actions must be urgently planned to reduce human–bear conflicts. Due to the size of the Apennine population, every single individual is crucial for the survival of this population, especially in the case of adult females, i.e., the loss of adult females greatly increases population vulnerability (Wilson & Castellucci 2006). Moreover, effective policies of damage mitigation and compensation need to be reinforced because carnivore damages to human property threaten human–carnivore coexistence and may undermine conservation efforts (Bautista et al. 2016; Fernández-Gil et al. 2016). Third, it will be necessary to continue sanitary monitoring of wild boars *Sus scrofa* to prevent the diffusion of Aujeszky's disease, a viral disease that might have been responsible of the death of one bear in the study area in 2012. Additionally, the management of the special protection area (ZPS) should also include specific rules for wild boar hunting with dogs because this activity may negatively interfere with bear presence and distribution. Finally, because we found a more or less continuous presence of both wintering and breeding bears throughout the study period, which confirms a stable presence of the species in this peripheral area of its distribution, we suggest that: (1) particular attention should be paid to the protection of the areas frequented by wintering bears and females with cubs, as well as denning areas; and (2) further genetic sampling of bears is strongly needed, particularly to investigate the presence of females with cubs.

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