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Space use patterns and genetic contribution of a reintroduced male Brown bear (*Ursus arctos*) in the Pyrenees between 1997 and 2011: the risk of genetic dominance of few males in reintroduced populations

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During the XX Century the Pyrenean Brown Bear (*Ursus arctos* Linnaeus, 1758) population dramatically declined from over 100 individuals to its disappearance at the end of the 1980s (Caussimont 1992, Alonso *et al.* 1993, Quenette *et al.* 2000). In 1996, a reintroduction program was conducted in Central Pyrenees. In this area, elevation ranges from 500 to 3,300 m., often with important slopes. Over 40% (France) and 50% (Spain) of the target area is forested, and over 30% (both countries) is composed by alpine and subalpine pastures (Quenette et al. 2000, Palazón et al. 2000). The aim of the program was 1) to check the adaptation of the introduced bears to the new habitat, and 2) to facilitate the acceptance of the presence of wild bears by the local human community (Quenette *et al.* 2000, Palazón *et al.* 2002).

Two females (1996) and one male (1997), called Pyros, were translocated from Slovenia to the Central Pyrenees (Quenette *et al.* 2000). In 2006, five more Slovenian individuals (four females and one male) were released (Ministry of Ecology 2006). As a result of both releases, the bear population has increased to an estimation of 25-30 individuals, of which 20 have been identified (Palazón *et al.* 2011).

Male Pyros was captured in Slovenia on 1th May 1997 and released in Melles (Haute Garonne, France), near the French-Spanish border, one day later. At this time it was 8-9 years old, and weighs 235 kg (birth year: 1988 or 1989) (Quenette *et al.* 2000). Until December 2011 this animal remained on this range continuously during 14.5 years, reaching its full maturity (23-24 years old). Pyros took out the transmitter collar in 1997, being recaptured and re-collared in Luchon valley, France, in 1998; once more Pyros took out the second collar.

Annual home ranges were estimated by means of (a) minimum convex polygons (MPC) and (b) Adaptative Kernel (ADK) (95% and 50% -core area-) (Worton 1989). Three different periods were defined based on the techniques used to track Pyros (all records gathered were geo-referenced in UTM system): 1) 1997-1998, terrestrial telemetry (VHS) (Telonics, Mod 600), obtaining locations by means of triangulation. Location was gathered daily, one per day to estimate daily movements; 2) 1999-2009, when Pyros did not carry collar, tracking was achieved by opportunistic data, as tracks, faeces, depredations and observations. Finally, 3) 2009-2011, photography and video automatic systems baited on a regular scheme (Mace *et al.* 1994) and hairs trapping for genetic analysis. The genetic analysis was carried out following the procedure described by Taberlet *et al.* (1997) and Taberlet (2000), based on a set of 11 microsatelytes of the nDNA. An analysis of each locus was done comparing the alleles with the possible progenitors in order to asses if Pyros or other males was the father of every cub.

Ranges in period (1) were larger from those published in Quenette *et al.* (2000) and Palazón *et al.* (2002) (Table 1 and Figure 1), but differences can be easily explained by the fact that we included in the analysis some new data, and a different procedure

Table 1. Annual home ranges size (in Km^2) of male Pyros in the Pyrenees, between 1997 and 2011, estimated by means of Minimum Convex Polygons (MPC) and Adaptative Kernel (95 and 50%) methods. Only home range sizes of years with more than 30 locations were estimated.

Year	Method[1]	Number of locations	MPC	Kernel (95%)	Kernel (50%)
1997	Radiotracking	119	700.9	1,163.1	106.5
1998	Radiotracking	257	1,311.9	694.5	69.4
1999	Oportunistic	47	176.9	218.7	29.16
2001	Oportunistic	36	360.7	1,191.4	295.9
2010	Trapping[2]	51	624.9	1,591.2	199.3
2011	Trapping[2]	68	336.3	1,100.1	225.2
Total (1997-2011)		628	2,273.1	1,093.5	97.6

1 Main method used.
2 Photography and genetically analysed hairs obtained in a regular scheme plus opportunistic data.

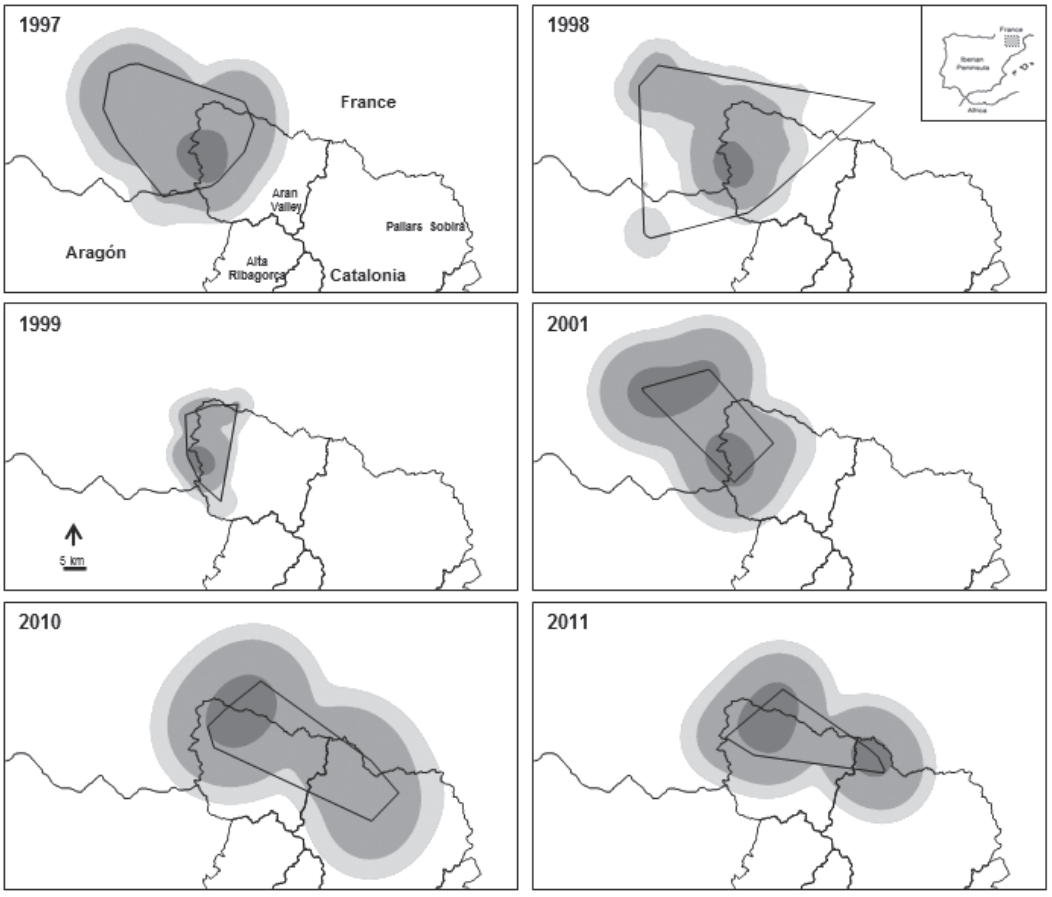

Figure 1. Annual home ranges of Pyros in Central Pyrenees, estimated from independent locations, in 1997, 1998, 1999, 2001, 2010 and 2011. Minimum Convex Polygons (100%) (straight line) and Adaptative Kernel (99, 95 and 50%) (surface). Last years, male moved between two core areas (Aran Valley and northern Pallars), 6 times in 2010 and 9 in 2011.

was used to avoid effects of autocorrelation. Nonetheless, home ranges obtained were similar in comparison with other european translocated Bears (Quenette *et al.* 2006), but larger than non-translocated ones in Europe (Huber & Roth 1993, Kaczensky 1999). Home ranges obtained in three periods were quite similar (1,100-1,200 km^2 per 1997, 2001, 2010 and 2011), even of fixes number varied from 36 to 119. However, we found extreme values for 1999 (219 km^2) and 2010 (up to 1,591 km^2). On average, annual home range was of 993.2 (SD = 474.6) km^2.

Overall, during the 15 years of monitoring, Pyros occupied a surface (Kernel 95 %) of 1,093.5 km^2, presenting extreme locations of 71 (W-E) and 52.5 (N-S) km. Considering only the core areas (Table 1 and Figure 1) we can see that Pyros spent most of their time in much smaller spots of 29-296 km^2 representing on average only 154.25 (SD = 102.22) km^2. This means on average 15.05% (SD = 6.24; range = 9.2-24.8) of the home range size. Home range and core area of Pyros moved to the East across the 15 calendar years of monitoring (Figure 1). Some different hypothesis could explain such changes, apparently no linked to changes in habitat and food distribution or fluctuations. One of the most consistent could be the distribution of the home ranges of females, because Pyros travelled often across them trying to copulate with adult mature females. But we can't conclude this one at the present. It must be demonstrated in future works with more detailed analysis.

Breeding history of Pyros started in Slovenia, when mated and fecundated two females. By chance, both females were captured and translocated to the Pyrenees in spring 1996, while being pregnant. In 1997 three (all from Pyros) and two -one from Pyros and another from a non-identified father, cubs were born(Bellemain *et al.* 2006). According to the comparison of microsatellites of cubs, and potential progenitors, we conclude that Pyros mated and fertilized seven different females (Table 2). A minimum of thirteen breeding events could be imputed to Pyros, plus other two in which we are not completely sure, giving a minimum of 23 cubs (9 males, 9 females and 5 non-identified; mean = 1.76 cubs per litter). It is interesting to emphasize that in seven occasions Pyros mated with non-related females (n= 4 different females), but in the remaining six mated with related females (n= 2): daughter and granddaughter. We point out that 75% of know born bear cubs (n= 31) during all these years were produced for this single male, despite we know the presence of a minimum of other two adult males in the area.

Results show that Pyros was perfectly adapted to the Pyrenean landscape, surviving for 15 calendar years, using a very large range, moving easily across the mountains, finding the small number of resident adult females, mating and producing a high number of offspring. However, there is a serious handicap as Pyros, who displayed some kind of breeding dominance, is the father, grandfather or ancestor of most of the bears born in this small reintroduced population, determining a high risk of genetic variation decreasing and inbreeding (first three released bears were captured in the same area, what means a higher possibility of relativeness). In the 2006 release, five bears (with only one male) were captured from two different Slovenian

Table 2. Number of reproductive events of Pyros, between 1996 and 2011, with different females (n = 6) and offspring (n = 23). m = male; f = female.

Copulation Year	Female	Birth Year	Cub 1	Cub 2	Cub 3	Observation
1996	Ziva	1997	Kouki (m)	-	-	In Slovenia [1]
1996	Mellba	1997	Caramelles (f)	Boutxy (m)	Medved?	In Slovenia [1]
2000	Caramelles	2001	Cub 1 (m) [2]	-	-	Daughter
2001 not sure	Ziva	2002	Cub 1	Cub 2	-	-
2001	Caramelles	2002	Caramellita (f)	Cub 2	-	Daughter
2003	Caramelles	2004	Cub 1 (m) [2]	Cub 2 (m)	-	Daughter
2005 not sure	Caramellita	2006	Moonboots (m)	-	-	Grand daughter
2006 not sure	Caramelles	2007	Bonabé (m)	-	-	Daughter
2008	Hvala	2009	Nhèu (f)	Noisette (f)	-	-
2009	Caramelles	2010	Pelut (m)	Plume (f)	-	Daughter
2009	Bambou	2010	Fadeta (f)	Floreta (f)	-	-
2010	Pollen	2011	Cub 1 (m) [3]	-	-	-
2010	Hvala	2011	Cub 1 (f)	Cub 2 (f)	Cub 3	-

1 Copulation in Slovenia, before capture.
2 Dead the same year by natural causes.
3 Dead the same year (possibly infanticide).

Reserves (Ministry of Ecology 2006), what means a new possibility. But the genetic contribution of this new male to bear population has been null, at least for the 2007-2011 seasons. However, more males (and females) and from different areas (to avoid the relativeness) must be released in the future to ensure the viability of this population. These results should be considered in future for this and other reintroduction programs. We point out that in small populations, and especially in incipient populations, some males can monopolize most of breeding events, threatening the viability and the success of a reintroduction project (Quenette *et al.* 2006) or a very small subsisting population. This seems to be our case, as it also was in Austria and Italy (Quenette *et al.* 2006). The pre-senile status of Pyros and the presence of other adult males within the population will probably allow females to have offspring from different males, but some are sons or grandsons of Pyros. Again, new males should be released to prevent such negative effects.

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