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#### ABSTRACT

We described an extension of the known distribution range of capercaillie into an atypical area and habitat for the species. Nine Cantabrian capercaillie *Tetrao urogallus cantabricus* leks and 14 cocks were registered in Mediterranean *Quercus pyrenaica* forests in an area of 1,500 km<sup>2</sup>, of which 4,500 forest hectares were surveyed. At present this population represents both the southern-most distribution for capercaillie and the only one inhabiting Mediterranean *Q. pyrenaica* forests, what suggests a wider adaptation of this (sub)species than previously thought. This capercaillie population and its habitat need to be better studied, as well as to be considered in conservation planning for Cantabrian capercaillie.

KEY WORDS: conservation, leks, Mediterranean, Quercus pyrenaica, Tetrao urogallus cantabricus, plasticity.

#### **INTRODUCTION**

2 Populations across distribution range show different adaptations to local 3 conditions from the core areas to the periphery of their distribution (Guo et al. 4 2003). In the case of capercaillie, the vast majority of populations inhabit boreal 5 and montane coniferous forests with abundant bilberry Vaccinium myrtillus 6 understory (Storch 1993; 2000a; 2000b, Storch 2001). However, the Cantabrian 7 subspecies Tetrao urogallus cantabricus (Cantabrian Mountains, NW Spain) 8 resides mainly in pure deciduous forests of beech Fagus sylvatica, birch Betula 9 pubescens and sessile oak Quercus petraea, as well as mixed forests of beech and 10 oaks (Quercus robur, Q. petraea, and Q. pyrenaica) (Bañuelos & Quevedo 2008). 11 In these forests holly *Ilex aquifolium* provides a key, evergreen winter food 12 resource for Cantabrian capercaillie (Storch 2001; Blanco-Fontao et al. 2009) 13 whereas it relies on bilberry in summer-autumn (Blanco-Fontao et al. 2009). 14 Previous studies showed, however, a negative selection to Quercus pyrenaica 15 forests by Cantabrian capercaillie at the northern slope of the Cantabrian range 16 (Quevedo et al. 2006b).

This endemic capercaillie subspecies is isolated and separated more than 300km from the nearest capercaillie population in the Pyrenees. After severe population decline in the last three decades (from 2,000 to 400 adults), only 108 leks remain occupied in the northern watershed and 85 leks in the southern, corresponding to an overall occupancy rate of 32% of all known leks (Bañuelos & Quevedo 2008). Consequently, Cantabrian capercaillie subspecies qualifies to be listed as "Endangered" according to the IUCN criteria (Storch et al. 2006).

24 Capercaillie populations have so far been generally considered to be 25 distributed in the Eurosiberian biogeographic region, outside Mediterranean

26 region (but see Handrinos and Akriotis 1997, Storch 2001; discussion section). 27 Unlike the Eurosiberian region, the Mediterranean region is characterized by a 28 period of drought during hot summer which determines the existing vegetation 29 (e.g., Penas 1995; Blondel & Aronson 1999; Rivas-Martínez et al. 2005). This 30 Mediterranean environment is thought to be unsuitable for a species primarily 31 adapted to boreal environments. However, there are historical records suggesting 32 capercaillie presence during 17th-19th centuries in Mediterranean areas in Spain 33 (Madoz 1848; Castroviejo 1975; Martínez 1993), but the first sighting record in 34 Q. pyrenaica forests in this Mediterranean area was unnoticed until May 1998 35 (Pollo et al. 2004) (No. 1 in Fig. 1).

In this study we present information on the number of cocks and characteristics of leks located in an atypical area and habitat for the capercaillie, i.e., Mediterranean *Q. pyrenaica* forests with virtual lack of bilberry and holly. This study is the first showing capercaillie widely present in this forest type, suggesting a wider ecological plasticity of this (sub)species than previously thought. We also discuss implications that this new capercaillie site may have in the conservation of Cantabrian capercaillie.

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#### MATERIAL & METHODS

45 *Study area* 

The study area is located on the southern slope of the Cantabrian Mountains in León province (NW Spain). It is centred at 42° 39'N and located in the Mediterranean biogeographical region bordering the Eurosiberian region (Atlantic) (Rivas-Martínez et al. 2004, European Environment Agency, 2008) (Fig. 1). The study area covers approximately 1,500km<sup>2</sup> below the putative line separating the two biogeographical regions in a landscape slightly mountainous (elevation ranges from 800 to 1,700 m.a.s.l.). It belongs to the biogeographical unit Carpetan-Leonese Subprovince from the Mediterranean region with supramediterranean bioclimate (Penas 1995, Rivas-Martínez et al. 2005, del Río et al 2007). A meteorological station from our study area (Villameca) clearly shows two dry months (P < 2T; Blondel & Aronson 1999) in summer: July (P=26; T=19.9) and August (P=19; T=19.1) (data based on 37 years).

58 Dominant forests are supramediterranean natural (more than 50 years old) and 59 post-fire *Q. pyrenaica* forests frequently occurring interspersed with Scots pine 60 *Pinus sylvestris* plantations (less than 50 years old). Both forest types are largely 61 monoespecific in the study area. *Q. pyrenaica* forests cover 27,000ha (19% of the 62 study area). Scots pine plantations occupy 11,000ha (8%).

*Q. pyrenaica* (Willd.) is a marcescent oak tree distributed widely in Spain as well as the western part of France and the northwest of Marocco. This tree develops under siliceous soils in Eurosiberian region as well as in the Mediterranean region with an extensive representation in this biogeographic region. In Spain, *Q. pyrenaica* represents the dominant species of different vegetation series (del Río et al 2007).

69 Forest fragments of the study area are embedded in a matrix mainly 70 composed of heather Erica australis 1,560ha (1%), brooms Genista florida and 71 Cytisus scoparius (hereafter C. scoparius) 3,640ha (3%), meadows 3,460ha (3%) 72 and riparian lowland forest of Populus nigra, Fraxinus excelsior and Alnus 73 glutinosa 5,340ha (4%). Understory cover is mainly dominated by heath Erica 74 arborea (hereafter E. arborea) and broom C. scoparius while bilberry and holly is 75 completely absent or very scarce (<0.5% of the forest ground cover) in the study 76 area. The remaining 62% surface corresponds with anthropogenic landscapes such

as villages, roads, opencast mines, valley bottoms, which are not suitable for capercaillie habitat. Human population is approximately 1,000 people (0.6 people/km<sup>2</sup>) and it has declined by 80% since the 1950's. Livestock rearing is the main economic activity in the study area, followed by coal mining industry, agriculture, forestry and hunting.

82

#### 83 Methods

84 No systematic sampling of the species was performed for the whole study area. We gathered information on capercaillie presence from 2002-2009 from two 85 86 sources: i) questionnaires and reports sent by forest wardens, hunters and local 87 people to the León environmental agency from the regional government 88 (Consejería de Medio Ambiente of the Junta de Castilla y León), and ii) field 89 surveys. Samples were recorded over the whole year. Data from the first source 90 were validated within two weeks after receipt of the sample through field surveys 91 carried out by an experienced observer (L. Robles). Field surveys consisted of a 3-92 4 hours systematic zig-zag walk looking for presence signs of capercaillie (e.g., 93 direct sightings, footprints, droppings or feathers), especially focusing on sites 94 known to be highly used by the species (e.g., forest paths, dead trunks, big stones, 95 oldest forest sites, etc.).

In forest patches bigger than 1km<sup>2</sup> (i.e., more than 3-4 hours of sampling required) we conducted surveys over consecutive days until covering the whole forest patch (i.e., a continuous forest isolated by a non-forest matrix). Direct sightings, footprints, droppings or feathers recorded in a site were considered as signs of capercaillie presence. Each forest patch was completely surveyed 6-10 times throughout one year, 1-2 months each between. If no sign of capercaillie

presence was found, the forest patch was labelled unoccupied and no furthersurveys were conducted in that specific patch.

Additionally, we surveyed the occupied patches in order to find leks. Selected sites were locations where survey after survey we found capercaillie signs. The visits were performed throughout April and May (i.e., display season) after 12 a.m. to avoid disturbing birds. A lek is defined as a site where one or more cocks consistently display for hens, plus the adjacent surrounding forest habitat. It has traditionally been used as capercaillie occurrence measure in the Cantabrian range (see Obeso & Bañuelos 2003).

During April-May where fresh capercaillie signs were found, 2-3 observers (forest wardens and L. Robles) visited the site at night as many as four times until the display finished, or until well past dawn. A site was considered as an occupied lek when at least one cock was heard calling or seen displaying.

Every detected lek was surveyed each year to label it as occupied or unoccupied just looking for presence signs after 12 a.m. (see above). In April-May 2009 every occupied lek was surveyed at night to get the number of displaying cocks.

119 Nine forest structure variables (Table 1) were measured in each lek 120 consisting of twelve circular plots with 5m radius. Three plots separated by 10 121 meters among them were arranged in each cardinal direction from the lek centroid 122 (i.e., the point where previously here a cock was recorded displaying).

125

#### RESULTS

126 A total of nine leks, including that discovered in 1998 (Pollo et al 2004), 127 were registered in the study area, seven of them remained occupied in 2009 (Fig. 128 2). The highest occupancy was in 2006 with eight occupied leks (Fig. 2). Since 129 2006 no new lek was found, despite an increase of around 2,000 additional 130 hectares surveyed (60% of the total surveyed surface, Fig. 2). Leks were grouped 131 into three subareas according to the watersheds: one subarea had three leks, other 132 had four and the last subarea had two (Fig. 1). Mean nearest neighbour distance 133 between leks was  $2.07 \pm 0.74$  kilometers (mean  $\pm$  SE). 134 Leks were in Q. pyrenaica forests ranging from 1,132 to 1,398 m.a.s.l. 135 (mean  $\pm$  SE: 1275  $\pm$  100.93, n=9) and mainly faced in a northerly direction with 136 two exceptions facing south (Table 1). They showed heterogeneity in the forest 137 structure, ranging from sites with young trees (perimeter  $0.19 \pm 0.005$  meters) 138 with high canopy cover  $(0.81 \pm 0.06\%)$  to mature trees (perimeter  $0.90 \pm 0.62$ 139 meters) with low canopy cover  $(0.28 \pm 0.07\%)$ . The maximum tree height in leks 140 varied from  $7.75 \pm 0.86$  meters to  $16.50 \pm 3.20$  meters (see Fig. 3). 141 Understory cover ranged from low (0.004  $\pm$  0.86%) to high (0.62  $\pm$ 

141 Olderstory cover ranged from 16w (0.004  $\pm$  0.30%) to high (0.02  $\pm$ 142 0.27%). In six of the nine leks the dominant understory species was *E. arborea* 143 while *C. scoparius* dominated the remaining one (Table 1).

In 2009 twelve cocks were recorded at the seven occupied leks. Moreover, two additional cocks not referred to any lek were detected during the spring 2009 fieldwork. Two nests with five and seven eggs each (both in *Q. pyrenaica* forest) were found in early June 2009 (Fig. 1, No 5 and 8).

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#### DISCUSSION

151 So far, capercaillie always occurred in the Eurosiberian biogeographical 152 region with the exceptions of the probably introduced birds of Mount Athos 153 (Greece; Handrinos and Akriotis 1997), currently extinct (S. Xirouchakis per. 154 comm.), and two other unclear data in Mount Grammos and Lailias Forest 155 Reserve in Greece (Storch 2001). Therefore, the capercaillie population we 156 described here represents both the southern-most distribution for capercaillie and 157 the only one inhabiting Mediterranean Q. pyrenaica forests. These forests are 158 different from the nearest ones occupied by capercaillie leks located north of the 159 putative line separating Eurosiberian and Mediterranean regions (Fig 1, Table 1 160 and 2). These northern leks are mainly located in birch and sessile oak forests 161 with understory dominated by bilberry (see Table 2) in a Eurosiberian bioclimatic 162 environment (superior montane thermotype and inferior humid ombrotype) (Penas 163 1995). Nonetheless lek 4, although in Q. pyrenaica forest, has an eurosiberian 164 bioclimatic environment (Penas 1995), probably because of its most northerly 165 relative position.

Despite an increase in the surveyed area, no new leks were found after 2006. However, the fact that we only surveyed 12% of the forest surface within our study area (Fig. 2), suggests new leks may be found in the future. Although the number of capercaillie in the study area is small, it represents approximately 7% of the global Cantabrian population, highlighting the conservation value of this site.

172 All the nine leks were located in *Q. pyrenaica* forests. Conversely no lek 173 was located in pure Scots pine plantations, although these were available in the 174 study area. In addition, two of four radio-tracked (one hen and one cock) capers 175 used all year round Q. pyrenaica forests of the studied area (authors, unpublished 176 data) and two capercaillie nests were discovered in these forests. All of this 177 suggests that Q. pyrenaica forests are suitable year-round habitat for the Cantabrian capercaillie. This is particularly important because the potential habitat 178 179 for this endangered subspecies could thus be greatly increased, as O. pyrenaica 180 forests are highly represented with > 100,000 hectares at the southern slope of the 181 Cantabrian Mountains (Gil-Sanchez & Torre-Antón 2007). Additionally, despite 182 the idea that Q. pyrenaica forests are not considered as suitable habitat (Quevedo 183 et al. 2006b) and neither are included in the recovery plans for the Cantabrian 184 capercaillie, our study highlights the need to take into account these forests for the 185 conservation of this subspecies. Nonetheless, the role of the pine plantations for 186 capercaillie in the study area should be further assessed.

187 Finally, this study supports what is suggested by Quevedo et al. (2006a; 188 2006b) and Blanco-Fontao et al. (2009) that many general considerations for the 189 species overall are not fully useful for the Cantabrian capercaillie, and suggests a 190 wider adaptation and plasticity of this species than previously thought. For 191 example, the near absence of bilberry and holly in the studied area suggest that 192 capercaillie can maintain viable populations without this important summer and 193 winter food resource for Cantabrian population and elsewhere (Storch 2001; 194 Blanco-Fontao et al. 2009). Future research could address a detailed comparison 195 of capercaillie suitable habitat between the two different biogeographical regions. 196 Studying the ecology and genetic variability of this local population living in this 197 atypical habitat would be of a great value to further understand and conserve this 198 subspecies in particular and *Tetrao urogallus* in general.

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#### 201 Zusammenfassung

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# 203 Der Mediterrane Pyrenäen-Eichenwald: ein neuer Lebensraum für das 204 Auerhuhn?

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- 205
- 206 Wir beschreiben eine Ausdehnung des bekannten Verbreitungsgebietes des
- 207 Auerhuhns in ein atypisches Gebiet und Habitat für diese Art. In einem 1,500 km<sup>2</sup>

208 großen Pyrenäen-Eichenwald Gebiet, wovon 4,500 ha Wald untersucht wurden,

- 209 konnten neun Balzarenen des Kantabrischen Auerhuhns Tetrao urogallus
- 210 cantabricus und 14 Hähne festgestellt werden. Aktuell repräsentiert diese
- 211 Population die sowohl südlichste Verbreitung von Auerhühnern als auch die
- 212 einzige, die mediterrane Pyrenäen-Eichenwälder bewohnt. Dieses weist auf eine
- 213 größere Anpassung dieser (Unter-)Art hin, als vorher vermutet. Diese Auerhuhn-
- 214 Population und ihr Lebensraum müssen jedoch noch besser untersucht werden
- 215 und sie sollte auch in Schutzstrategien für das Kantabrische Auerhuhn
- 216 berücksichtigt werden.

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#### APPENDIX

Appendix 1. Description of the leks (n=9) in the study area (see  $\bullet$  in the map of the study area). Mean  $\pm$  SE are shown for forest structure variables of the leks.

Footnote: Lek = lek number by discovery date; Date = year when the lek was first-time recorded (April-May); Cocks = No. of capercaillie cocks recorded in each lek in 2009; m. a. s. l. = elevation (meters above the sea level); Exp. = exposure in the slope; Tree Perimeter = mean trees perimeter measured in DBH (diameter at breast height). Tree Height = mean trees height; Cover = mean canopy cover (%); Species = tree dominant species; Height = mean understory height (meters); Cover = mean understory cover (%); Species = understory dominant specie.

					Trees			Understory			
Lek.	Date	Cocks	m a. s. l.	Exp.	Perimeter (m)	Height (m)	Cover (%)	Species	Height(m)	Cover (%)	Species
1	1998	2	1215	NW	$0.45\pm0.17$	$9.42 \pm 1.38$	$0.57\pm0.21$	Q. pyrenaica	$1.12\pm0.38$	$0.39\pm0.25$	C. scoparius
2	2002	1	1131	NW	$0.90\pm0.62$	$16.50\pm3.20$	$0.58\pm0.15$	Q. pyrenaica	$0.85\pm0.07$	$0.25\pm0.06$	C. scoparius
3	2002	0	1154	NW	$0.32\pm0.15$	$9.17 \pm 1.75$	$0.54\pm0.26$	Q. pyrenaica	$0.75\pm0.50$	$0.16\pm0.17$	E. arborea
4	2003	2	1230	NE	$0.70\pm0.13$	$7.75\pm0.86$	$0.28\pm0.07$	Q. pyrenaica	$1.33\pm0.24$	$0.45\pm0.25$	E. arborea
5	2004	3	1387	Ν	$0.70\pm0.15$	$14.08 \pm 2.81$	$0.64\pm0.22$	Q. pyrenaica	$0.03\pm0.08$	$0.004\pm0.01$	C. scoparius
6	2006	1	1253	Ν	$0.20\pm0.05$	$9.50\pm0.42$	$0.60\pm0.25$	Q. pyrenaica	$0.50\pm0.42$	$0.51 \pm 1.41$	E. arborea
7	2006	0	1356	Ν	$0.23\pm0.06$	$11.17\pm0.38$	$0.47\pm0.24$	Q. pyrenaica	$0.79\pm0.25$	$0.39\pm0.57$	E. arborea
8	2006	2	1351	SE	$0.43\pm0.10$	$10.33 \pm 1.37$	$0.58\pm0.15$	Q. pyrenaica	$1.37\pm0.31$	$0.40\pm0.17$	E. arborea
9	2006	1	1398	SW	$0.19\pm0.05$	$10.16\pm0.57$	$0.81 \pm 0.06$	Q. pyrenaica	$1.42\pm0.45$	$0.62\pm0.27$	E. arborea

Appendix 2. Description of the Eurosiberian leks (n=17) north of the study area (see Fig 1). Mixed in "Tree species" involves no tree species as dominant, but occurring mixed: *Betula pubescens*, *Q. petraea*, *Q. pyrenaica* and *Sorbus aucuparia*.

Lek	m.a.s.l.	Exposure	Tree species	Understory species
1	1440	N-W	Q. petraea	Vaccinium myrtillus
2	1520	N-W	Mixed	Vaccinium myrtillus
3	1450	N-W	Mixed	Vaccinium myrtillus
4	1550	N-E	Mixed	Vaccinium myrtillus
5	1490	Ν	Q. petraea	Vaccinium myrtillus
6	1620	Ν	Betula pubescens	Erica arborea
7	1650	Ν	Betula pubescens	Erica arborea
8	1550	Ν	Betula pubescens	Erica arborea
9	1680	Ν	Betula pubescens	Erica arborea
10	1590	N-E	Betula pubescens	Vaccinium myrtillus
11	1680	Ν	Betula pubescens	Vaccinium myrtillus
12	1620	N-W	Mixed	Vaccinium myrtillus
13	1540	N-W	Mixed	Vaccinium myrtillus
14	1510	N-W	Betula pubescens	Erica arborea
15	1590	Ν	Betula pubescens	Erica arborea
16	1620	N-E	Betula pubescens	Vaccinium myrtillus
17	1590	N-W	Mixed	Vaccinium myrtillus

#### FIGURE LEGENDS

FIG. 1. Area of occupancy of Cantabrian capercaillie in 1980 (Obeso & Bañuelos 2003) (black left) and study area (right). Numbers correspond to the leks according to the discovery date. Lek 1 was the first capercaillie breeding record in *Q. pyrenaica* forest in 1998. Solid line represents the border between the Eurosiberian and the Mediterranean biogeographical regions after European Environment Agency -EEA- 2008 and Rivas-Martínez et al (2004). (•) represent the recently discovered Mediterranean leks while ( $\blacktriangle$ ) represent the traditional Eurosiberian leks. According to the government restrictions, leks location is slightly moved for security. Light and dark grey dominating the area represents *Pinus sylvestris* and *Q. pyrenaica* forests, respectively.

FIG. 2. Occurrence of the Mediterranean leks since 2002. Bars show the total accumulated forest surface surveyed (ha) through the study years. Solid line represents the occupied leks and broken line the known leks.

FIG. 1



FIG. 2



Year