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The Mediterranean *Quercus pyrenaica* oak forest: a new habitat for the Capercaillie?

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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 km², 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

1
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).

17 This endemic capercaillie subspecies is isolated and separated more than
18 300km from the nearest capercaillie population in the Pyrenees. After severe
19 population decline in the last three decades (from 2,000 to 400 adults), only 108
20 leks remain occupied in the northern watershed and 85 leks in the southern,
21 corresponding to an overall occupancy rate of 32% of all known leks (Bañuelos &
22 Quevedo 2008). Consequently, Cantabrian capercaillie subspecies qualifies to be
23 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).

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

43

44 MATERIAL & METHODS

45 *Study area*

46 The study area is located on the southern slope of the Cantabrian
47 Mountains in León province (NW Spain). It is centred at 42° 39'N and located in
48 the Mediterranean biogeographical region bordering the Eurosiberian region
49 (Atlantic) (Rivas-Martínez et al. 2004, European Environment Agency, 2008)
50 (Fig. 1). The study area covers approximately 1,500km² below the putative line

51 separating the two biogeographical regions in a landscape slightly mountainous
52 (elevation ranges from 800 to 1,700 m.a.s.l.). It belongs to the biogeographical
53 unit Carpetan-Leonese Subprovince from the Mediterranean region with
54 supramediterranean bioclimate (Penas 1995, Rivas-Martínez et al. 2005, del Río
55 et al 2007). A meteorological station from our study area (Villameca) clearly
56 shows two dry months ($P < 2T$; Blondel & Aronson 1999) in summer: July ($P=26$;
57 $T=19.9$) 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%).

63 *Q. pyrenaica* (Willd.) is a marcescent oak tree distributed widely in Spain
64 as well as the western part of France and the northwest of Marocco. This tree
65 develops under siliceous soils in Eurosiberian region as well as in the
66 Mediterranean region with an extensive representation in this biogeographic
67 region. In Spain, *Q. pyrenaica* represents the dominant species of different
68 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

77 as villages, roads, opencast mines, valley bottoms, which are not suitable for
78 capercaillie habitat. Human population is approximately 1,000 people (0.6
79 people/km²) and it has declined by 80% since the 1950's. Livestock rearing is the
80 main economic activity in the study area, followed by coal mining industry,
81 agriculture, forestry and hunting.

82

83 *Methods*

84 No systematic sampling of the species was performed for the whole study
85 area. We gathered information on capercaillie presence from 2002-2009 from two
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.).

96 In forest patches bigger than 1km² (i.e., more than 3-4 hours of sampling
97 required) we conducted surveys over consecutive days until covering the whole
98 forest patch (i.e., a continuous forest isolated by a non-forest matrix). Direct
99 sightings, footprints, droppings or feathers recorded in a site were considered as
100 signs of capercaillie presence. Each forest patch was completely surveyed 6-10
101 times throughout one year, 1-2 months each between. If no sign of capercaillie

102 presence was found, the forest patch was labelled unoccupied and no further
103 surveys were conducted in that specific patch.

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

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

115 Every detected lek was surveyed each year to label it as occupied or
116 unoccupied just looking for presence signs after 12 a.m. (see above). In April-
117 May 2009 every occupied lek was surveyed at night to get the number of
118 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).

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RESULTS

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A total of nine leks, including that discovered in 1998 (Pollo et al 2004), were registered in the study area, seven of them remained occupied in 2009 (Fig. 2). The highest occupancy was in 2006 with eight occupied leks (Fig. 2). Since 2006 no new lek was found, despite an increase of around 2,000 additional hectares surveyed (60% of the total surveyed surface, Fig. 2). Leks were grouped into three subareas according to the watersheds: one subarea had three leks, other had four and the last subarea had two (Fig. 1). Mean nearest neighbour distance between leks was 2.07 ± 0.74 kilometers (mean \pm SE).

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Leks were in *Q. pyrenaica* forests ranging from 1,132 to 1,398 m.a.s.l. (mean \pm SE: 1275 ± 100.93 , n=9) and mainly faced in a northerly direction with two exceptions facing south (Table 1). They showed heterogeneity in the forest structure, ranging from sites with young trees (perimeter 0.19 ± 0.005 meters) with high canopy cover ($0.81 \pm 0.06\%$) to mature trees (perimeter 0.90 ± 0.62 meters) with low canopy cover ($0.28 \pm 0.07\%$). The maximum tree height in leks varied from 7.75 ± 0.86 meters to 16.50 ± 3.20 meters (see Fig. 3).

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Understory cover ranged from low ($0.004 \pm 0.86\%$) to high ($0.62 \pm 0.27\%$). In six of the nine leks the dominant understory species was *E. arborea* while *C. scoparius* dominated the remaining one (Table 1).

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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).

149

150

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.

166 Despite an increase in the surveyed area, no new leks were found after
167 2006. However, the fact that we only surveyed 12% of the forest surface within
168 our study area (Fig. 2), suggests new leks may be found in the future. Although
169 the number of capercaillie in the study area is small, it represents approximately
170 7% of the global Cantabrian population, highlighting the conservation value of
171 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
178 Cantabrian capercaillie. This is particularly important because the potential habitat
179 for this endangered subspecies could thus be greatly increased, as *Q. 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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200

201 **Zusammenfassung**

202

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

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 km²
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 ● in the map of the study area). Mean ± 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.

Lek.	Date	Cocks	m a. s. l.	Exp.	Trees				Understory		
					Perimeter (m)	Height (m)	Cover (%)	Species	Height(m)	Cover (%)	Species
1	1998	2	1215	NW	0.45 ± 0.17	9.42 ± 1.38	0.57 ± 0.21	<i>Q. pyrenaica</i>	1.12 ± 0.38	0.39 ± 0.25	<i>C. scoparius</i>
2	2002	1	1131	NW	0.90 ± 0.62	16.50 ± 3.20	0.58 ± 0.15	<i>Q. pyrenaica</i>	0.85 ± 0.07	0.25 ± 0.06	<i>C. scoparius</i>
3	2002	0	1154	NW	0.32 ± 0.15	9.17 ± 1.75	0.54 ± 0.26	<i>Q. pyrenaica</i>	0.75 ± 0.50	0.16 ± 0.17	<i>E. arborea</i>
4	2003	2	1230	NE	0.70 ± 0.13	7.75 ± 0.86	0.28 ± 0.07	<i>Q. pyrenaica</i>	1.33 ± 0.24	0.45 ± 0.25	<i>E. arborea</i>
5	2004	3	1387	N	0.70 ± 0.15	14.08 ± 2.81	0.64 ± 0.22	<i>Q. pyrenaica</i>	0.03 ± 0.08	0.004 ± 0.01	<i>C. scoparius</i>
6	2006	1	1253	N	0.20 ± 0.05	9.50 ± 0.42	0.60 ± 0.25	<i>Q. pyrenaica</i>	0.50 ± 0.42	0.51 ± 1.41	<i>E. arborea</i>
7	2006	0	1356	N	0.23 ± 0.06	11.17 ± 0.38	0.47 ± 0.24	<i>Q. pyrenaica</i>	0.79 ± 0.25	0.39 ± 0.57	<i>E. arborea</i>
8	2006	2	1351	SE	0.43 ± 0.10	10.33 ± 1.37	0.58 ± 0.15	<i>Q. pyrenaica</i>	1.37 ± 0.31	0.40 ± 0.17	<i>E. arborea</i>
9	2006	1	1398	SW	0.19 ± 0.05	10.16 ± 0.57	0.81 ± 0.06	<i>Q. pyrenaica</i>	1.42 ± 0.45	0.62 ± 0.27	<i>E. arborea</i>

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	<i>Q. petraea</i>	<i>Vaccinium myrtillus</i>
2	1520	N-W	Mixed	<i>Vaccinium myrtillus</i>
3	1450	N-W	Mixed	<i>Vaccinium myrtillus</i>
4	1550	N-E	Mixed	<i>Vaccinium myrtillus</i>
5	1490	N	<i>Q. petraea</i>	<i>Vaccinium myrtillus</i>
6	1620	N	<i>Betula pubescens</i>	<i>Erica arborea</i>
7	1650	N	<i>Betula pubescens</i>	<i>Erica arborea</i>
8	1550	N	<i>Betula pubescens</i>	<i>Erica arborea</i>
9	1680	N	<i>Betula pubescens</i>	<i>Erica arborea</i>
10	1590	N-E	<i>Betula pubescens</i>	<i>Vaccinium myrtillus</i>
11	1680	N	<i>Betula pubescens</i>	<i>Vaccinium myrtillus</i>
12	1620	N-W	Mixed	<i>Vaccinium myrtillus</i>
13	1540	N-W	Mixed	<i>Vaccinium myrtillus</i>
14	1510	N-W	<i>Betula pubescens</i>	<i>Erica arborea</i>
15	1590	N	<i>Betula pubescens</i>	<i>Erica arborea</i>
16	1620	N-E	<i>Betula pubescens</i>	<i>Vaccinium myrtillus</i>
17	1590	N-W	Mixed	<i>Vaccinium myrtillus</i>

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 (▲) 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

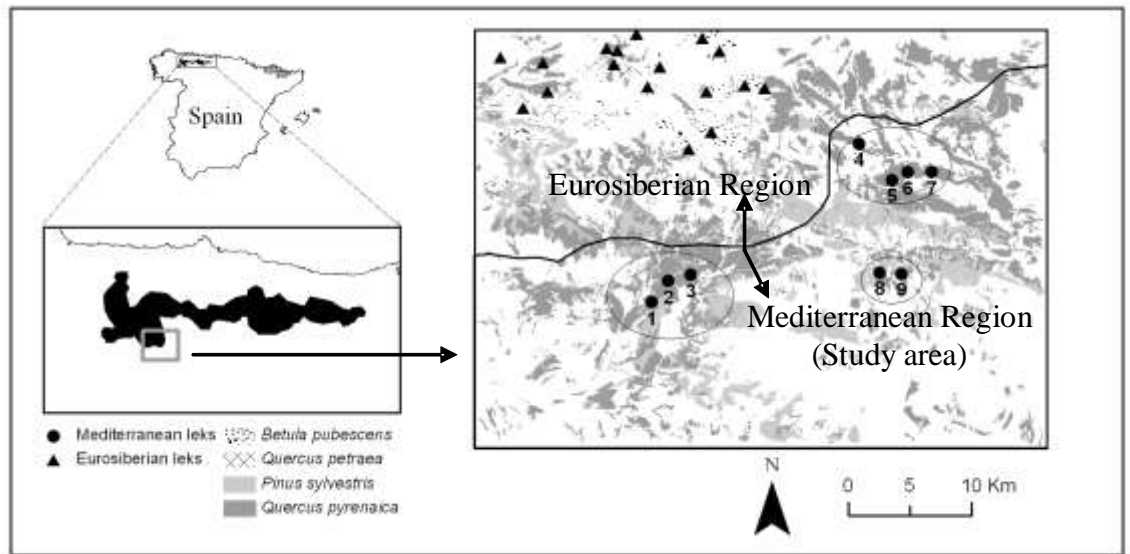


FIG. 2

