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Abstract

This comprehensive species-specific chapter covers all aspects of the mammalian biology, including paleontology, physiology, genetics, reproduction and development, ecology, habitat, diet, mortality, and behavior. The economic significance and management of mammals and future challenges for research and conservation are addressed as well. The chapter includes a distribution map, a photograph of the animal, and a list of key literature.

**Iberian Wild Goat *Capra pyrenaica*
Schinz, 1838**

Ricardo García-González, Juan Herrero, Pelayo Acevedo,
Mari Cruz Arnal, and Daniel Fernández de Luco

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20 **Common Names**

21 English	Iberian wild goat
German	Iberischer Steinbock
French	Bouquetin Iberique
Spanish	Cabramontés ibérica
Italian	Stambecco iberico
Russian	Dikaya koza дикаякоза

species. The probable genetic proximity between 36
C. ibex and *C. pyrenaica* (Manceau et al. 1999) 37
 does not necessarily imply a proximity of 38
 morphotypes (Pidancier et al. 2006), as is the 39
 case, for example, between *C. falconeri* and *C.* 40
aegagrus (Zvy chaynaya 2010). 41

42 **Taxonomy, Paleontology,**
 43 **and Systematics**

Taxonomy. The original description of the species 44
 by Schinz (1838) was based on a male specimen 45
 from the Zürich Museum and on skins and draw- 46
 ings from Carl F. Bruch. Schinz never saw a live 47
C. pyrenaica, and, in his publication, he noted that 48
 they were extremely rare in the Pyrenees. Ten 49
 years later, Schimper (1848) described a new spe- 50
 cies of *Capra* for Iberia, *C. hispanica*, relying on 51
 specimens collected in an expedition to Sierra 52
 Nevada (Southern Iberia) in 1847. Thus, until 53
 the twentieth century, taxonomically, two species 54
 of wild goat occurred in Iberia. 55

AU2 22 The name of Spanish ibex to designate *Capra*
 23 *pyrenaica* occurs in the scientific literature, and
 24 some have defended its appropriateness (Sarasa
 25 et al. 2012); however, in our opinion, the desig-
 26 nation is inappropriate. Etymological, historical,
 27 biological, and human societal arguments support
 28 the use of “Iberian wild goat” as common name
 29 (García-González et al. submit). *C. pyrenaica*
 30 is not an ibex. Adult males have tyre-shaped and
 31 typically smooth horns (Fig. 1), which do not
 32 correspond to the ibex morphotype, which have
 33 scimitar-shaped and knotted horns (Pidancier
 34 et al. 2006). In addition, *C. pyrenaica* is an Iberian
 35 endemism, and not an exclusively Spanish

Fig. 1 Iberian wild goats:
 adult male, adult female,
 and goatling



56 In an influential article, Cabrera (1911) modi- 103
 57 fied substantially the taxonomy of the Iberian wild 104
 58 goat. Cabrera combined into a single species, 105
 59 *C. pyrenaica*, the two species described initially 106
 60 by Schinz, *C. pyrenaica*, and Schimper, 107
 61 *C. hispanica*, which he designated as subspecies, 108
 62 and he described two new subspecies: *lusitanica* 109
 63 and *victoriae*. Therefore, the current taxonomical 110
 64 classification at the intraspecific level accepted by 111
 65 the IUCN (Shackleton and Lovari 1997) is *Capra* 112
 66 *pyrenaica* Schinz, 1838, with four subspecies: 113
 67 *C. p. pyrenaica* Schinz, 1838 (extinct); *C. p.* 114
 68 *hispanica* Schimper, 1848; *C. p. lusitanica* Schlegel, 115
 69 1872 (extinct), and *C. p. victoriae* Cabrera, 1911. 116

70 *Terra typica* of the nominotypical subspecies 117
 71 *C. p. pyrenaica* was found in the Pyrenees, 118
 72 although it was extremely rare there during the 119
 73 twentieth century (García-González and Herrero 120
 74 1999). The last Pyrenean wild goat died in 121
 75 January 2000 (Fernández de Luco et al. 2000). 122
 76 *C. p. hispanica* occurs throughout the mountains 123
 77 and steep slopes in Southern and Eastern Iberia 124
 78 and, recently, has expanded its range rapidly (see 125
 79 “Current Distribution”). *C. p. lusitanica* inhabited 126
 80 Northern Portugal and, like the Pyrenean wild 127
 81 goat, was rare. Barboza du Bocage (1857) wrote 128
 82 the first detailed description of the Portuguese 129
 83 subspecies. It became extinct at the beginning of 130
 84 the twentieth century. *C. p. victoriae* lives in the 131
 85 mountains of the center and northwest of the 132
 86 Iberian Peninsula, and Cabrera (1911) defined it 133
 87 as an intermediate form between *pyrenaica* and 134
 88 *hispanica*.

89 Cabrera (1911, 1914) based the subspecies 135
 90 definition on a few specimens and on highly vari- 136
 91 able characters, i.e., the pattern of the black hair 137
 92 on the male winter dress and the shape of the 138
 93 horns (Schaller 1977). Couturier (1962) and 139
 94 Clouet (1980) questioned that classification. The 140
 95 subspecies definition of Cabrera was also rejected 141
 96 by Camerano (1917) who defended the recogni- 142
 97 tion of the two original forms that had the greatest 143
 98 divergence of characteristics in Iberia, 144
 99 *C. pyrenaica* and *C. hispanica*, which he felt 145
 100 should be considered distinct species. Hybridiza- 146
 101 tion between those species led to the other geo- 147
 102 graphic varieties (*victoriae*, *lusitanica*). 148

103 Although some have identified environmental 104
 105 differences in the ecological niches of the two 106
 107 living subspecies, *victoriae* and *hispanica* 108
 109 (Acevedo and Real 2011), recent morphological 110
 111 (García-González 2012) and molecular studies 112
 113 (Angelone-Alasaad et al. 2017; Ureña et al. 114
 115 2018) have indicated that the two share a close 116
 117 kinship and a clear genetic distance from the 118
 119 extinct Pyrenean subspecies. *C. p. pyrenaica* is 120
 121 genetically and morphologically as far from the 122
 123 *victoriae-hispanica* group, as it is from the Alpine 124
 125 ibex *C. ibex* (Manceau et al. 1999; Ureña et al. 126
 127 2018). Thus, it is logical to return to the original 128
 129 proposal of Schinz (1838) and Schimper (1848), 130
 131 supported by Camerano (1917); namely, two 132
 133 species in Iberia, the extinct *C. pyrenaica* and 134
 135 *C. hispanica*.

136 Paleontology. The oldest fossil records of 137
 138 *Capra* in Eurasia were found in Fonelas P-1 139
 140 (Southeastern Iberia); they date to the beginning 141
 142 of the Pleistocene (2.0 Ma) and belong to *Capra* 143
 144 *baetica* (Arribas and Garrido 2008). Other ancient 145
 146 fossils of *Capra* such as *C. alba* from the Early 147
 148 Pleistocene (1.3–1.0 Ma) have been found in 149
 150 Venta Micena (Moyà-Solà 1987) and Quibás 151
 152 (Carlos Calero et al. 2006), also in Southeastern 153
 154 Iberia. Findings of *Capra* sp. from the Middle Pleis- 155
 156 tocene are much less abundant (García-González 157
 158 2011). In Iberia and in Southern France, *Capra* 159
 160 records from the Upper Pleistocene are numerous, 161
 162 many of which assigned to *C. pyrenaica* (Sauqué 163
 164 et al. 2016). 165

166 The relationship between the ancient goats 167
 168 from the Early and Middle Pleistocene and the 169
 170 extant and the Upper Pleistocene *C. pyrenaica* is 171
 172 unknown. Possibly, those ancient Iberian goats 173
 174 became extinct; however, that *Capra* had been 175
 176 present on the Iberian Peninsula continuously 176
 177 throughout the Pleistocene cannot be denied 177
 178 (Couturier 1962; Montoya et al. 2001; García- 178
 179 González 2011), with episodes of introgressions 179
 180 with the neighboring taxon, *Capra ibex*, from the 180
 181 Alps (see “Genetics”). 181

182 Systematics. The double-wave migratory 182
 183 hypothesis of Crégut-Bonnoure (1992, 2006) 183
 184 posits that the ancestors of *C. ibex* from the 184
 185 Alps, of the type *C. camburgensis*, arrived in 185
 186 France in a first migratory wave that came from 186

151 the Near East at the end of the Middle Pleistocene.
 152 In a second migratory wave, a common ancestor
 153 of *C. pyrenaica* and the complex *caucasica*
 154 *cylindricornis* arrived to the Massif Central in
 155 France during the Eemian (130,000–
 156 115,000 years BCE). That ancestor, *C. caucasica*
 157 *praepyrenaica*, evolved to become *C. pyrenaica*,
 158 which spread into Southern France and reached
 159 the Pyrenees in the Magdalenian (17,000–
 160 12,000 years BCE) without interbreeding with
 161 *C. ibex*. Following that hypothesis, *C. pyrenaica*
 162 colonized Iberia (Cabrera 1911) through the Pyr-
 163 enees after 18,000 years. Recently, the validity
 164 of that theory has been questioned. *C. pyrenaica*
 165 has been present in Iberia for more than
 166 40,000 years BCE (Sauqué et al. 2016); there is
 167 high variability in the differential morphological
 168 characters proposed by Crégut-Bonnoure
 169 (Magniez 2009); and kinship between *C. ibex*
 170 and *C. pyrenaica* is likely and supported by
 171 molecular (Pidancier et al. 2006; Ureña et al.
 172 2018) and morphological studies (García-
 173 González 2012).

174 Alternatively, the single-wave migratory the-
 175 ory, mainly based on studies of molecular genetics
 176 (Manceau et al. 1999; Ureña et al. 2018), posits
 177 that *C. ibex* and *C. pyrenaica* are a monophyletic
 178 clade. They should have come from a common
 179 ancestor related to *C. camburgensis* also coming
 180 from the Middle East. Nevertheless, most studies
 181 suggest the time of divergence between *C. ibex*
 182 and *C. pyrenaica* did not coincide with the age of
 183 *C. camburgensis*. Manceau et al. (1999) estimated
 184 the divergence time of the two species to be
 185 between 2.5 and 0.5 million years, which is con-
 186 gruent with the estimates of Lalueza-Fox et al.
 187 (2005) and Pérez et al. (2014), who estimated
 188 the divergence time to be 0.6 and 0.72 million
 189 years, respectively. Ureña et al. (2018) analyzed
 190 fossil and recent material of *C. pyrenaica* and
 191 estimated the divergence time to be only
 192 90,000–50,000 years BCE.

193 Overall, the actual systematic position of the
 194 Iberian goat is yet to be determined; however, it
 195 seems likely that *C. pyrenaica* was already present
 196 in the Iberian Peninsula and differentiated in the
 197 Late Pleistocene. Introgression by hybridization
 198 seems to be common in the evolution of the *Capra*

199 genus (Ropiquet and Hassanin 2006), and
 200 *C. pyrenaica* might have a polyphyletic origin
 201 through the intervention of hybridization pro-
 202 cesses with *C. ibex* and other ancient *Capra* taxa.

Current Distribution

203
 204 Distribution. Cabrera (1911) first reported that the
 205 species occurred in most of the mountainous areas
 206 of Iberia until the nineteenth century. High hunt-
 207 ing pressure and landscape changes, including
 208 those related to the increase of extensive livestock
 209 farming, caused a remarkable reduction in popu-
 210 lation size and distribution range in the nineteenth
 211 century and the first half of the twentieth century,
 212 and the species only survived in some isolated
 213 populations (e.g., Alados 1997). The status of
 214 the species remained the same until the 1960s
 215 when the population of Sierra de Cazorla was
 216 the only one whose distribution was clearly
 217 defined (Rodríguez de la Zubía 1969; De la
 218 Cerda and De la Peña 1971). Also in the 1960s,
 219 the establishment of Game Reserves in Spain has
 220 been fundamental to understand the population
 221 recovery of wildlife in general and game species
 222 in particular (Pita Fernández et al. 2012). From the
 223 1960s onward, the species was translocated to
 224 several locations, mainly using individuals from
 225 Sierra de Cazorla and Tortosa and Beseit Game
 226 Reserve for the subspecies *C. p. hispanica* and
 227 from Sierra de Gredos and the Batuecas Game
 228 Reserve for the subspecies *C. p. victoriae*. This
 229 significantly expanded the species' range to the
 230 current distribution (Acevedo and Cassinello
 231 2009a; see also "Management"). More recently,
 232 several studies have assessed the species' distri-
 233 bution throughout its range (e.g., Alados 1997)
 234 and in particular its expansion (González et al.
 235 2013).

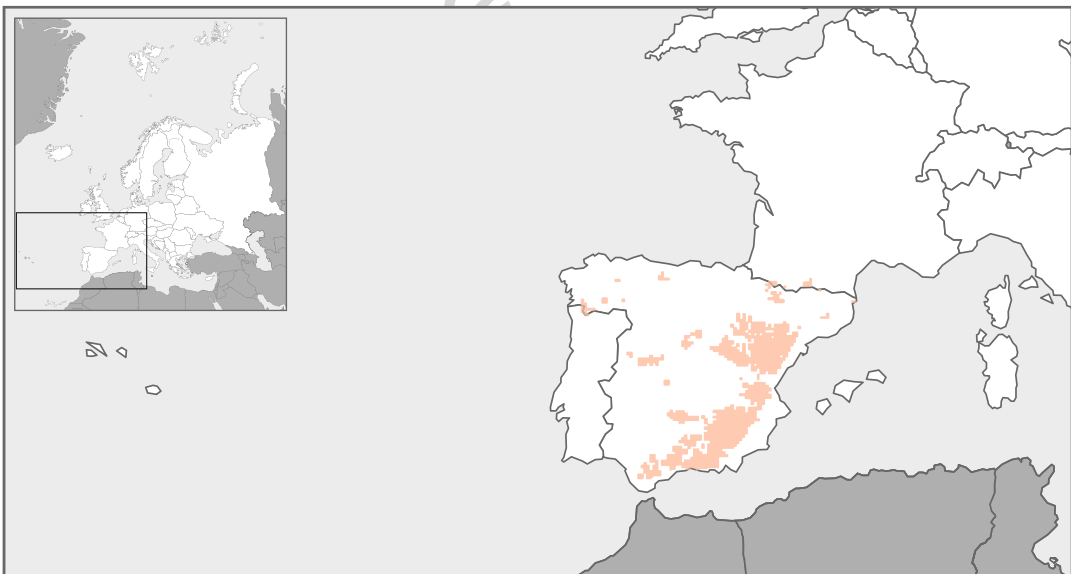
236 The first exhaustive revision on the species
 237 distribution and status identified more than
 238 50 populations (Pérez et al. 2002). In the 1990s,
 239 the distribution range generally increased, but
 240 with some heterogeneity among populations
 241 (Acevedo et al. 2007a; Cano-Manuel et al.
 242 2010). Information on the species presence in
 243 Spain was compiled at the beginning of this

244 century (Granados et al. 2002). In this period, the
245 species returned to Portugal after an escape from
246 Spain (Moço et al. 2006). Acevedo and Cassinello
247 (2009a) updated the information on its complete
248 Iberian range. Since the 1980s, the species started
249 the recolonization of the Pyrenees (Herrero et al.
250 2013b) in Spain. New reinforcements on the
251 French Pyrenees created two new populations
252 (Herrero et al. 2020, in press). All these
253 populations are expanding.

254 Currently, the species occupies most of the
255 mountain ranges in Eastern Iberia and the Central
256 Mountain Range and is particularly abundant in
257 Sierra de Guadarrama, Sierra de Gredos, Batuecas
258 Game Reserve, and the surrounding areas. In
259 Northern Spain, the population of the Cantabrian
260 Mountains is well established in Riaño Game
261 Reserve and Ancares Game Reserve, and the spe-
262 cies has expanded across the Northern Portuguese
263 border (Fonseca et al. 2017b). According to recent
264 data, the current distribution of the Iberian wild
265 goat is shown in Fig. 2 (Acevedo and Cassinello
266 2009a; Fonseca et al. 2017a). In most nuclei, there
267 has been a generalized expansion of the species'
268 range. Currently, the species occupies 926 10 ×

269 10 km UTM squares, of which 47.8% have been
270 occupied since 2008. Population densities range
271 from <1 to >30 individuals km⁻² (Escós and
272 Alados 1988; Escós et al. 1994; Pérez et al.
273 1994, 2002; Granados et al. 2001a, 2004; Torres
274 et al. 2014; Refoyo et al. 2014; Prada et al. 2019).

275 Abundance. The methods used to count ani-
276 mals and estimate population numbers include
277 block count from trails or vantage points and
278 distance sampling. Although a proper estimate of
279 the total number of Iberian wild goat has not been
280 conducted, current assessments suggest that it is
281 well over 100,000 animals. Some examples in
282 Spain are Sierra Nevada (15,000), Sierra de
283 Gredos (8,000), Iberian System (more than
284 50,000), Serranía de Ronda and Sierra de
285 Grazalema (4,000), Sierra de Cazorla (4,000),
286 Sierra Tejada y Almijara (2,500), Sierras de Ante-
287 quera (2,000), and Sierra Morena (2,000); for
288 Portugal and Spain, Peneda Geres National Park
289 and Baixa Limia and Serra do Xurés Natural
290 Park and surroundings (over 600 individuals);
291 and for the Pyrenees, French Pyrenees (about
292 400 individuals) and Spanish Pyrenees (over
293 400) (Herrero et al. 2020, in press).



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Fig. 2 Distribution of Iberian wild goat

AU6

294 **Description**

295 Pelage. Males have a black patch on their shoul- 303
 296 ders, which increases in size with age (Fig. 1) 304
 297 the young have brown-reddish fur and old males 305
 298 are brown or dark gray. Molts occur in spring and in 306
 299 winter. The summer coat is short and smooth, 307
 300 while the winter coat is long and compact. Iberian 308
 301 wild goats have elastic tissues between digits, 309
 302 which facilitate their movement in rugged terrain. 310
 311
 312
 313

Size and morphology. Head-body length is 303
 about 140 cm in males and 130 cm in females. 304
 Height at the withers is 70–90 cm in males and 305
 75 cm in females (Table 1). Females grow more 306
 rapidly than males until 3–4 years of age, and 307
 males grow quickly until 5 or 6 years old and 308
 reached the maximum value at about 9 years of 309
 age. Males reach 80 kg and females 46 kg (for a 310
 review, see Fandos and Vigal 1988, and Granados 311
 et al. 2001a). Central and northern animals are 312
 larger than the southern ones (Granados et al. 1997). 313

t1.1 **Table 1** Live body mass (in kg), body size, and horn size (in cm) from several Iberian wild goat populations. When more 303
 t1.2 than two individuals were measured, the mean and standard deviation are given. M = males; F = females 304
 AU8

	Sex	Body mass	Body length	Cross height	Horn length	Basal horn perimeter
t1.2 Pyrenees						
t1.3 Schinz (1838)	M		154–155	87–83	77–46	
t1.4	F		129	67		
t1.5 Cabrera (1911)	M				74.6 (10) 12	25 (6) 14
t1.6 Cabrera (1914)	M		148	75	86	26
t1.7	F				26.8	14
t1.8 García-González et al.	M	(70) ^a			60.2 (18) 15,8	23.9 (15) 1.9
t1.9 (unpublished)	F	41.5–55	138.5–133	76–83	22.3 (5) 3.7	12.6 (4) 0.9
t1.10 Sierra de Gredos						
t1.11 Cabrera (1911)	M				70.6 (10) 6.5	23.7 (10) 2.8
t1.12 Cabrera (1914)	M		135.5	70	73.2 (3) 8,3	24.4 (3) 2.1
t1.13	F				16.5	10
t1.14 Fandos and Vigal (1988) ^b	M	58.1 (23) 8.1			74.5 (4) 3.4	
t1.15	F	36.1 (17) 4.5			24.3 (12) 3.8	
t1.16 García-González et al.	M				49.6 (24) 10	21.2 (22) 1.5
t1.17 (unpublished)	F				19.4 (27) 5.2	10.2 (27) 0.8
t1.18 Sierra de Cazorla						
t1.19 Fandos and Vigal (1988) ^b	M	50.9 (45) 9			67.1 (8) 3.7	
t1.20	F	30.1 (29) 4.4			16.1 (18) 2	
t1.21 Fandos (1991)	M	56	132.7	81		
t1.22	F	31	112.8	69,5		
t1.23 García-González et al.	M				53.3 (44) 1.3	19.7 (44) 1.9
t1.24 (unpublished)	F				15.3 (33) 2.2	8.9 (33) 0.6
t1.25 Sierra Nevada						
t1.26 Granados et al. (1997)	M	50.4 (123) 11.9	108.6 (100) 11.3	79,3 (100) 5.7	47.5 (137) 16.1	20.7 (138) 2.2
t1.27	F	31.3 (73) 5.2	96.9 (62) 9	69 (62) 4.3	13.9 (72) 2.7	9.7 (71) 0.83
t1.28 Cabrera (1911)	M				62.9 (8) 7	21.6 (7) 1.9
t1.29 Cabrera (1914)	M		121	65.5	73.3	18.9
t1.30 Portugal						
t1.31 França (1917)	M		142–138	73–74	36–44.5	23.5
t1.32	F		120 (3) 19.2	67 (4) 3.2	18.2 (4) 7	10.5 (3) 1.7

t1.33 ^aEstimated from Fandos et al. (1989) equations

^bLive body mass: males >5 years; females >4 years. Horn length: males >9 years; females >8 years

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314 Iberian wild goat exhibits strong sexual size
315 dimorphism, with males being much larger than
316 females (Fandos and Vigal 1993). Both sexes
317 have horns that have a circular section and rings,
318 with each ring representing 1 year of age. Envi-
319 ronmental factors influence the size of the rings
320 (Fandos 1995). Male horns reach up to 1 m in
321 length.

322 Dentition. 0.0.3.3 / 3.1.3.3 (Vigal and
323 Machordom 1987).

324 Physiology

325 The physiology of Iberian wild goat is similar to
326 that of most temperate European mountain ungu-
327 lates. Pérez et al. (2003a) reported hematological
328 and biochemical reference values for free-
329 ranging, physically restrained, and clinically nor-
330 mal animals, which have provided key diagnostic
331 information. Statistical significant differences
332 between sexes and age classes were reported for
333 hematocrit/hemoglobin (males>females; lower
334 when older), cholesterol (females>males; lower
335 when older), triglycerides (females>males; lower
336 when older), creatine kinase (females>males;
337 lower when older), alkaline phosphatase
338 (males>females; lower when older), proteins
339 (males>females; higher when older), and Mg
340 (females>males; lower when older). Even though
341 the hematological parameters can be useful in
342 monitoring wild goat physiological status (Pérez
343 et al. 2006), pathogens such as sarcoptic mange
344 can reduce eosinophils levels, likely mediated by
345 the density of mites (Pérez et al. 2015), which
346 highlights the importance of individual health sta-
347 tus in physiological assessments.

348 Serum proteins and triglycerides are reliable
349 indicators of body condition in Iberian wild
350 goats (Serrano et al. 2008). Body condition was
351 also studied from kidney fat stores (Serrano et al.
352 2011; see also Santos et al. 2013). Body condition
353 varies seasonally; fat stores are highest in the
354 warmest months and lowest in the coldest months,
355 although with sex- and age-specific differences
356 (Serrano et al. 2011). Males have higher reserves
357 than females; however, in winter, body condition
358 decreases more in males than in females, and

359 goatlings need one season more than young or
360 adults to restore their reserves. In addition, popu-
361 lation density has negative effects on fat reserves,
362 especially in winter, possibly owing to intraspe-
363 cific competition when food resources are limited
364 (Serrano et al. 2011).

Genetics

365 Chromosomes. Iberian wild goat has $2n = 60$
366 chromosomes.

367 Genetic Diversity. Molecular studies in *Capra*
368 genus have produced contradictory results that dif-
369 fer based on the technique used (Pidancier et al.
370 2006), although all agree that the kinship between
371 Iberian wild goat and Alpine ibex is close (Manceau
372 et al. 1999; Kazanskaya et al. 2007; Zvychnayna
373 2010; Bibi et al. 2012; Hassanin et al. 2012).

374 Few comparative studies are available on the
375 molecular genetics of current Iberian populations,
376 including the Alpine ibex. An early study based
377 on the cytochrome b gene of mitochondrial DNA
378 (mtDNA) found that the Pyrenean wild goat dif-
379 ferentiated clearly from the other Iberian
380 populations, with a similar genetic distance
381 between these (4.9%) and Alpine ibex (5.3%)
382 (Manceau et al. 1999). In addition to the Pyrenean
383 lineage, this study identified two evolutionarily
384 significant units (ESU): one group that included
385 the original populations in Northern Iberia (Sierra
386 de Gredos, Tortosa and Beseit Game Reserve) and
387 Muela de Cortes Game Reserve and another from
388 the South (Sierra Nevada National Park, Sierra de
389 Cazorla, and Ronda-Grazalema).

390 Ten haplotypes were identified in *Capra*
391 populations from Southern Iberia when studying
392 the variability of the cytochrome b gene of
393 mtDNA, seven of which occurred in the Sierra
394 Nevada population (Márquez et al. 2002).
395 Manceau et al. (1999) also detected a high genetic
396 diversity in that population, which probably did
397 not experience severe bottlenecks. Based on
398 Marquez et al. (2002) and unpublished data,
399 three ESU have been identified (Pérez et al.
400 2002): *C. p. pyrenaica* in the Pyrenees, *C. p.*
401 *victoriae* in Sierra de Gredos and surrounding
402 areas, and *C. p. hispanica* in Southeastern Iberia
403

404 which are, in principle, in agreement with the
 405 subspecies recognized by Cabrera (1914). More
 406 recent studies suggest that the molecular genetic
 407 differences between *C. p. victoriae* and *C. p.*
 408 *hispanica* are not consistent. Using microsatellite
 409 markers, Angelone-Alasaad et al. (2017) found that
 410 the genetic divergence between two populations
 411 (East Iberian System and Sierra Nevada) of the
 412 same subspecies, *C. p. hispanica*, was greater
 413 (31.5%) than the divergence with a population
 414 (Sierra de Gredos, 24.8%) belonging to another
 415 subspecies, *C. p. victoriae*. Using ancient mtDNA
 416 techniques and next-generation sequencing tech-
 417 nologies, three major clades of *Capra* were identi-
 418 fied in Western Europe (Ureña et al. 2018): *C. ibex*,
 419 *C. p. pyrenaica*, and the group comprising the
 420 subspecies *hispanica* and *victoriae*. This genetic
 421 structure indicates the distinctiveness of the Pyre-
 422 nean wild goat from the other Iberian wild goats
 423 and suggests that this group is an ESU.

424 Hybridization. Hybridization between domes-
 425 tic goat *C. hircus* and *C. pyrenaica* in captivity or
 426 artificial conditions is well-known (Fernández-
 427 Arias et al. 1999; Alasaad et al. 2012). Under
 428 natural conditions, there are well-founded suspi-
 429 cions of its occurrence, although it is not frequent,
 430 possibly because of physiological and behavioral
 431 barriers. Placental incompatibility, immunologi-
 432 cal rejection, and differences in gestation length
 433 (162 ± 2 days in Iberian wild goat and 150 days in
 434 domestic goat) are potential limiting factors
 435 (Fernández-Arias et al. 2001).

436 Recently, in several isolated populations of
 437 Iberian wild goat in Southern Iberia, Angelone
 438 et al. (2018) found an MHC allele characteristic
 439 of the domestic goat, which suggests past hybrid-
 440 ization. Given numerous official and not-official
 441 translocations among different regions, introgres-
 442 sion between subspecies of *C. pyrenaica* might
 443 have occurred (Manceau et al. 1999; Acevedo and
 444 Cassinello 2009a).

445 Life History

446 Growth. Average body mass at birth is 2.2 kg
 447 (Fandos 1989). Asymptotic body mass is reached
 448 at 3–4 years of age in females and at *c.* 9 years of

449 age in males, leading to strong sexual size dimor- 449
 450 phism (cf. Description). Compensatory horn 450
 451 growth does not occur in male Iberian wild goats 451
 452 (Carvalho et al. 2017). A reduction in horn length 452
 453 was documented, probably caused by harvest 453
 454 practice (Pérez et al. 2011), and the synergistic 454
 455 effect of harvest practice and habitat changes 455
 456 (Carvalho et al. 2020). 456

457 Reproduction. Typically, the number of 457
 458 goatlings per female is one, but twins are frequent 458
 459 (Rodríguez de La Zubía 1969; Fandos 1989). 459
 460 After parturition, adult females tend to stay alone 460
 461 in sheltered areas, protected from predators, 461
 462 mainly golden eagle *Aquila chrysaetos*. After 462
 463 that, mothers gather and care for their kids while 463
 464 sharing vigilance. 464

465 Females typically reach sexual maturity at 465
 466 30 months of age, when they weigh at least 466
 467 24 kg (Fandos 1989, 1991), but sexual maturity 467
 468 can occasionally occur earlier (Granados et al. 468
 469 2001a). In captivity, they reach sexual maturity 469
 470 at *c.* 12–16 months (Fernández-Arias et al. 1997). 470
 471 Gestation lasts 23–24 weeks (Fandos 1991). Rut 471
 472 peaks at the beginning of December, and parturi- 472
 473 tion starts in the second half of April and peaks in 473
 474 the second half of May in Southern Iberia (Fandos 474
 475 1988b, 1989; Alados and Escós 1988, 1996). 475

476 Information on male breeding success is not 476
 477 available. 477

478 Survival. Sex ratio at birth can be biased 478
 479 toward males both in the wild (Escós 1988) and 479
 480 in captivity (Fernández-Arias et al. 1997). Mortal- 480
 481 ity rate is high among young animals up to 481
 482 3 years of age, stable until 8 years of age in 482
 483 males and 10–11 years of age in females, and 483
 484 high in both sexes thereafter (Fandos 1991). 484
 485 Males and females can reach 14 and 19–22 years 485
 486 of age, respectively (Fandos 1991). 486

Habitat and Diet 487

488 Habitat use and selection. At the species range 488
 489 scale, the Iberian wild goat is mostly associated 489
 490 with forested areas that have high levels of insola- 490
 491 tion and outcrops (Acevedo and Real 2011). 491
 492 Those results are consistent with studies 492
 493 performed with a biogeographical perspective at 493

494 regional scales (Acevedo et al. 2007a, b; Acevedo
495 and Cassinello 2009b) and also in semiarid envi-
496 ronments (Lucas et al. 2016).

497 At the population scale, the Iberian wild goat
498 uses forested landscapes on high-slope areas
499 (Acevedo et al. 2011a). Males occur at higher
500 elevations than females, probably because of the
501 sexual differences in nutritional requirements (see
502 below; Gonzalez 1982; Escós and Alados 1992b).
503 In autumn, individuals select sunny slopes at dusk
504 and dawn (in spring, at dusk only); in summer,
505 however, they prefer northern slopes (Escós and
506 Alados 1992b). In spring and summer, wild goats
507 in the Sierra Nevada National Park occupy north-
508 east- and northwest-facing slopes, while in
509 autumn and winter they dwell on slopes facing
510 south or southeast. In the Sierra de Cazorla popu-
511 lation, due to milder climatic conditions, there are
512 no significant differences in the seasonal variation
513 of selected exposures (Escós and Alados 1992b).
514 Climate severity influences seasonal patterns of
515 habitat use within the species' distribution range;
516 extreme weather conditions occur both in summer
517 and in winter. In addition to topography, food qual-
518 ity is an important factor influencing the seasonal
519 patterns of the species' habitat use. For instance,
520 partial vertical migrations are frequent in summer,
521 owing to higher nutritional quality of the vegeta-
522 tion at high elevation pastures (Gonzalez 1982;
523 Escós 1988; Fandos and Martínez 1988). Further-
524 more, seasonal variations in dietary quality
525 (Acevedo et al. 2011a) and body condition
526 (Carvalho et al. 2015) suggested that primary pro-
527 ductivity influences the species' habitat use.

528 Sex, habitat availability, and season influence
529 the home range size of Iberian wild goat at the
530 individual scale. Females have smaller home
531 ranges than males, and ranges are larger in spring
532 than in autumn (e.g., Viana et al. 2018). In Sierra
533 de Cazorla, the average home range for females
534 was 0.81 km² in spring and 0.25 km² in autumn,
535 whereas in males the home range was 4.28 km² in
536 spring and 1.05 km² in autumn (Escós and Alados
537 1992a). In addition, habitat suitability and popu-
538 lation density negatively correlates with home
539 range (Escós and Alados 1988; Viana et al.
540 2018). All animals exhibited rut area fidelity, but
541 females only showed fidelity to the area used in

542 spring. During the rut, males can show dispersal
543 movements of over 7 km (Escós and Alados
544 1992a).

545 Diet. Members of the *Capra* genus classify as
546 browsers. In *C. pyrenaica* several studies showed
547 high browse proportions in their diet, 61% and
548 72% in Sierra de Cazorla (Martínez et al. 1985;
549 Cuartas et al. 1996, respectively), 71% in Tortosa
550 and Beseit Game Reserve (Martínez 1994), and
551 83% in Sierra Tejada (Martínez 1988), and holm
552 oak leaves *Quercus rotundifolia* and *Q. ilex* were
553 one of the main browse species (García-González
554 and Cuartas 1992a). Food availability, however, is
555 one of the main factors that influence diet selec-
556 tion (Ellis et al. 1976), and, in open habitats or
557 alpine pastures, herbaceous vegetation predomi-
558 nates in the diet of Iberian wild goats: 57.5%
559 grasses in Sierra Nevada (Martínez 2002) and
560 80% grasses in Sierra de Gredos (Martínez and
561 Martínez 1987). Therefore, the species can be
562 more precisely classified as an intermediate feeder
563 based on Hofmann's (1989) feeding type classifi-
564 cation or more accurately as an intermediate
565 feeder with preference for browsing based on
566 Van Soest (1994).

567 Moço et al. (2013) described different feeding
568 behaviors at two neighboring areas in Northern
569 Portugal (grazer in Gerês but browser in
570 Amarela). Wild goats from Sierra de Gredos had
571 greater tooth wear of those in Sierra de Cazorla,
572 possibly due to the increased consumption of
573 grasses, richer in silica content (Fandos et al. 1993).

574 As an intermediate feeder, the Iberian wild goat
575 exhibits high forage selectivity and tries to avoid
576 consuming fibrous forage (Hofmann 1989). For-
577 aging is opportunistic with pronounced seasonal
578 differences in diet, reflecting changes in forage
579 quality. For instance, in Sierra de Cazorla, the
580 consumption of woody species is higher in
581 September than in February and in May, as the
582 end of summer is a dry and poor resource season
583 in Mediterranean ecosystems. The highest propor-
584 tion of forbs in the diet is in May, and consump-
585 tion of grasses is similar in May and February.
586 Number of plant species, diet diversity, and die-
587 tary quality are higher in May than in September
588 or February (Cuartas and García-González 1992).
589 In forest habitats, goats can cause serious damage

590 to preferred plants if population density is high
591 (Perea et al. 2015).

592 Intrinsic factors such as sex-age class can also
593 affect diet selection. In Sierra de Cazorla, adult
594 males ate more browse (77%) than herbs (23%),
595 the young ate more herbs (67%) than browse
596 (33%), and adult females ate similar proportions
597 of both (52% vs 48%) (Alados and Escós 1987).

598 Dietary overlap with other ungulates. In an
599 area in Sierra de Cazorla used simultaneously by
600 Iberian wild goat, red deer *Cervus elaphus*, and
601 fallow deer *Dama dama*, Iberian wild goat and red
602 deer had similar diets and a high overlap index
603 (74%), which increased in winter when food
604 resources were reduced (García-González and
605 Cuartas 1992b). Fallow deer had a different diet,
606 which included a higher proportion of grasses and
607 rather low overlap indexes with wild goat (34%)
608 and red deer (42%). The coexistence of the three
609 intermediate feeders might have been based either
610 on a divergence of habitat (red deer) or on a
611 deviation of the trophic niche (fallow deer).

612 Some studies have investigated the diet of Iberian
613 wild goat and domestic goats that shared the
614 same habitat. In Sierra de Cazorla, domestic goats
615 had an almost exclusively woody diet, but the
616 Iberian wild goat exhibited a more eclectic diet,
617 which reflected available vegetation (Cuartas and
618 García-González 1992). In the Pre-Pyrenees, feral
619 goats showed highly selective feeding behavior,
620 which was considered “a feature that distin-
621 guished them from their domestic counterparts
622 and approach them to wild goats” (Aldezabal
623 and Garin 2000).

624 Behavior

625 Social behavior. Males and females segregate
626 most of the year, except during the rutting season
627 (Granados et al. 2001a). Sexual segregation
628 reflects differences in sexual size dimorphism
629 and thus sex-specific ecological requirements
630 that lead to different habitat use and selection at
631 local scales (Alados 1985). This pattern, however,
632 appears somewhat simplistic because mixed
633 groups can occur throughout the year in some
634 populations, except in August (e.g., Alados and

635 Escós 1996). Several hypotheses have been pro-
636 posed to explain the differences between
637 populations (see Acevedo and Cassinello
638 2009a), but no empirical studies have been carried
639 out so far to disentangle the processes underlying
640 the differences in segregation patterns.

641 As in many other ungulates, the mother-kid
642 pair is the basic unit of organization (Alados and
643 Escós 1996). However, as a gregarious species,
644 other forms of social units occur, including groups
645 of females with kids, groups of adult males, and
646 groups of yearlings (males or females) (Alados
647 1985). In the Southern Iberian populations,
648 mixed groups (adult or young) are common. Gra-
649 nados et al. (2001a) found that 44.5% of the
650 individuals observed in Andalusian populations
651 formed mixed groups, 22.4% were groups of
652 females with kids, and 20.2% were all-male
653 groups, although the proportions vary seasonally.
654 Density affects positively population proportion
655 of mixed groups. In Sierra de Cazorla, a high-
656 density population, the proportion of individuals
657 in mixed groups was larger, greater than 40%
658 throughout the year, and was highest (up to
659 80%) during the rut. However, in Sierra Nevada
660 National Park, a low-density population, mixed
661 groups were only common during the rut (Alados
662 1985; Alados and Escós 1996).

663 Granados et al. (2001a) reported that the aver-
664 age group size in Andalusian populations was 5.2
665 individuals, larger than the average sizes of
666 all-male groups (4.9), female groups (3.2), and
667 female with kid groups (4.2) but smaller than the
668 average size of mixed groups (6.9). In addition,
669 population density positively influences group
670 size. Outside the rut, Alados and Escós (1996)
671 reported an average group size of 3.7 individuals
672 in Sierra Nevada National Park and 3.0 in Sierra
673 de Cazorla, which are intermediate between the
674 group sizes to those reported by Nievergelt (1974)
675 for the Alpine ibex (7.6) and the walia ibex
676 *C. walie* (1.5). Open habitats favor large groups,
677 while closed habitats favor small groups (Alados
678 1985, 1986b).

679 Activity. The time spent in different activities
680 (eating, moving, and resting) varies daily and
681 seasonally. In winter, activities that involve move-
682 ments occur around midday hours (Alados

683 1986c). In summer, goats are most active during
684 night hours and at dawn and dusk. In winter,
685 displacement movement occurs throughout the
686 day; in summer, however, they move at night
687 (Fandos 1988a). Males spend less time eating
688 than females, and males interact more with
689 males than with females, especially during rut.
690 The foraging behavior of subadult males is more
691 similar to that of females than to that of adult
692 males (Alados 1986c).

693 Mating behavior. The Iberian wild goat is a
694 polygynous species. Males establish a hierarchy
695 during rut, which dictates access to estrus females
696 (Alados 1986a; Álvarez 1990). Alados (1984; 2002), as well as Cystocaulus ocreatus, Dictyocaulus
697 1986a) and Fandos (1991) described Iberian
698 wild goat rutting behavior. Resources allocated
699 to reproduction in polygenic species are biased
700 toward females because males only invest signif-
701 icantly in reproduction in those years in which the
702 social hierarchy should be established (Granados
703 et al. 2001a).

704 Parasites and Diseases

705 Wild goat can suffer many pathologies, but
706 sarcoptic mange appears to be the only pathology
707 that can cause severe mortality.

708 Ectoparasites. Sarcoptic mange caused by
709 *Sarcoptes scabiei* is the main epizootic disease
710 that affects Iberian wild goat population dynamics
711 (Acevedo and Cassinello 2009a). Several out-
712 breaks of sarcoptic mange have occurred, with
713 different population crashes. The first foci were
714 in the late 1980s and 1990s in the Sierra de
715 Cazorla, where a population reduction of 81%
716 occurred (Fandos 1991; León-Vizcaíno et al.
717 1999), Sierra Nevada National Park (Pérez et al.
718 1997), and Sierra Mágina (Palomares and Ruiz
719 Martínez 1993). At the beginning of the twentieth
720 century, mange affected Iberian wild goat in
721 Muela de Cortes Game Reserve (Sánchez-Isarria
722 et al. 2008). In 2014, an outbreak occurred in
723 Tortosa and Beseit Game Reserve (Mentaberre
724 et al. 2015).

725 Sporadically, mild infestations by *Demodex*
726 sp. have occurred in Northeastern Iberia (Revilla
727 2012). Several ticks affect the species:

Dermacentor marginatus, *D. reticulatus*, 728
Haemaphysalis sulcata, *H. punctata*, *Hyalomma* 729
marginatum marginatum, *H. lusitanicum*, *Ixodes* 730
ricinus, *I. ventralloii*, *Rhipicephalus bursa*, and 731
R. sanguineus (Hueli and Díaz 1989; Antón 732
et al. 2002; García-Moreno et al. 2009; Varela- 733
Castro et al. 2018). Less frequent and lesser- 734
known ectoparasites are lice such as *Bovicola* 735
crassipes, *B. alpine*, and *Linognathus stenopsis* 736 AU11
(Antón et al. 2002). 737

738 Endoparasites. Parasites found in the respira- 739
tory system are *Oestrus caucasicus* larvae, known 740
as nasal myiasis (Pérez et al. 1996; Antón et al. 741
Cystocaulus ocreatus, *Dictyocaulus* 742
filaria, *Neostrongylus* sp., *Muellerius capillaris*, and 743
Protostrongylus sp. that colonize the bronchi and 744
lungs (Antón et al. 2002; Alasaad et al. 2009).

745 Digestive abomasum helminths are 746
Haemonchus contortus, *Marshallagia marshalli*, 747
M. occidentalis, *Ostertagia lyrata*, *O. ostertagi*, 748
Teladorsagia circumcincta, *T. davtiani*, and 749
T. trifurcata. In the small intestine, *Nematodirus* 750
davtiani, *N. abnormalis*, *N. filicollis*, *N. oiratianus*, 751
N. spathiger, *Trichostrongylus axei*, *T. capricola*, 752
T. colubriformis, and *T. vitrinus* (Rossi et al. 1992; 753
Lavin et al. 1997; Pérez et al. 2003b, 2006; Revilla 754
2012) occur. In addition, in the large intestine 755
Chabertia ovina, *Oesophagostomum venulosum*, 756
Skrjabinema sp., and *Trichuris ovis* occur (Rossi 757
et al. 1992; García-Moreno et al. 2009; Revilla 758
2012).

759 Described coccidiosis are *E. arloingi*, 760
E. aspheronica, *E. bakuensis*, *E. capraovina*, *E.* 761
caprina, *E. christenseni*, *E. faurei*, *E. folchijevi*, 762
E. gonzalezi, *E. hirci*, *E. ninakohlykimovae*, *E.* 763
ovina, and *E. parva* (Cordero del Campillo et al. 764
1994; Granados et al. 2001; Antón et al. 2002; 765 AU12
García-Moreno et al. 2009).

766 Larval form of cestodosis as hydatid cyst 767
(*Echinococcus granulosus*), *Coenurus cerebralis* 768
(*Multiceps multiceps*), and *Cysticercus tenuicollis* 769
(*Taenia hydatigena*) has been detected in the Ibe- 770
rian wild goat (Antón et al. 2002; Oleaga-Pérez 771
et al. 2003; Pérez et al. 2006; Revilla et al. 2007). 772
Other cestodes include *Monezia expansa* and 773
M. benedeni (Antón et al. 2002; Pérez et al. 2006) 774
Fasciola hepatica and *Dicrocoelium* 775
dendriticum exhibit low egg production in the

776 feces of Iberian wild goat (Antón et al. 2002;
777 Pérez et al. 2006; Alasaad et al. 2008; Refoyo
778 et al. 2016).

779 Various serological studies have shown anti-
780 bodies against *Sarcocystis* sp. (Granados et al.
781 2001; Antón et al. 2002; Luzón et al. 2008;
782 Santiago-Moreno et al. 2010), *Babesia* sp. (Ferrer
783 et al. 1998; García-Moreno et al. 2009), *Toxo-*
784 *plasma gondii*, and *Neospora caninum* (Gauss
785 et al. 2006; Almería et al. 2007; García-Bocanegra
786 et al. 2012). There was no detection of seroprevalence
787 against *Besnoitia* sp. in Iberian wild goat
788 (Gutiérrez-Expósito et al. 2016).

789 Infectious diseases. Brucellosis has low sero-
790 prevalence: 0.5% (Muñoz et al. 2010), 0.9%
791 (Antón et al. 2002), 3.6% (Carvajal et al. 2007),
792 and 6% (León-Vizcaíno et al. 1994). Identification
793 of *B. melitensis* occurred in three populations
794 (Cubero et al. 2002; León-Vizcaíno et al. 2009;
795 Muñoz et al. 2010).

796 Tuberculosis is a disease under study
797 (Fernández de Luco and Arnal 2002; Mentaberre
798 et al. 2010; Revilla 2012), and only one adult
799 female with the disease has been detected (Cubero
800 et al. 2002).

801 The detection of salmonellosis by *S. enterica*
802 serovar Enteritidis occurred in one clinical case
803 with septicemia (Navarro-González et al. 2014).
804 Other subspecies have been isolated from asymp-
805 tomatic animals: *S. enterica* serovar Enteritidis
806 (Navarro-González et al. 2014), *S. arizonae*
807 (González-Candela et al. 2006), *S. typhimurium*,
808 and *S. paratyphi* C (Cubero et al. 2002).

809 Infectious keratoconjunctivitis caused by
810 *Mycoplasma conjunctivae* is less severe among
811 free-ranging animals (Cubero et al. 2002; Arnal
812 et al. 2009; Revilla 2012) than it is among captive
813 animals, which can be affected by severe outbreaks
814 (Fernández-Aguilar et al. 2017).

815 Serological studies have been conducted to
816 investigate bacterial infections such as contagious
817 agalactia (León-Vizcaíno et al. 1994; Cubero et al.
818 2002), Q fever, and borreliosis (Santiago-Moreno
819 et al. 2011; Candela et al. 2017).

820 Sporadically, isolated bacteria have been iso-
821 lated: *Arcanobacterium pyogenes*, *Corynebacte-*
822 *rium pseudotuberculosis*, *E. coli*, *E. coli* O157:
823 H7, *Erysipelothrix rhusiopathiae*, *Fusobacterium*

necrophorum, *Klebsiella* sp., *Mannheimia* 824
haemolytica, *Mycobacterium avium para-* 825
tuberculosis, *Pasteurella multocida*, *Pseudomo-* 826
nas sp., *Staphylococcus* spp., *Streptococcus* sp., 827
and *Streptococcus* β -hemolytic (Cubero et al. 828
2002; Revilla et al. 2007; Revilla 2012; Colom- 829
Cadena et al. 2014; Navarro-González et al. 2015; 830
Arnal et al. 2016; Pizzato et al. 2017; Varela- 831
Castro et al. 2017). 832

833 Viral diseases are present but their impact on
834 wild populations is unknown. Some examples are
835 as follows: contagious ecthyma (Cubero et al. 835
2002; Revilla 2010; Camacho et al. 2017), blue- 836
tongue (García et al. 2009; Lorca-Oró et al. 2011; 837
Santiago-Moreno et al. 2011; Revilla 2012), small 838
ruminant lentivirus (Carvajal et al. 2007; García- 839
Moreno et al. 2009; Martín-Atance and León- 840
Vizcaíno 2009; Santiago-Moreno et al. 2011; 841
Revilla 2012), and pestivirus (Astorga-Márquez 842
et al. 2014, Fernández-Sirera et al. 2011). 843

844 Neoplasia. Several neoplasms have been
845 observed in Iberian wild goat: KIT-positive gas- 845
trointestinal stromal tumors (Velarde et al. 2008), 846
pheochromocytoma, cutaneous horn, intestinal 847
leiomyoma, thyroid carcinoma tumor (Arnal 848
et al. 2006), and disseminated melanoma (Arnal 849
and Fernández de Luco 2017). 850

851 Population Ecology

852 Population dynamics. Multiple factors can regu-
853 late the dynamics of Iberian wild goat
854 populations. Populations typically show a
855 density-dependent growth pattern, where density
856 mainly affects reproduction and goatling survival
857 but does not have a significant effect on adult
858 survival and fecundity (Escós et al. 1994; Escós
859 and Alados 1998), at least in the range of densities
860 considered in these studies. Escós and Alados
861 (1988) reported an adult survival rate of 0.87, a
862 breeding success (i.e., kids-to-adult females ratio
863 in summer) of 0.27, and an annual growth rate of
864 0.98 for the Iberian wild goat population in
865 Cazorla Game Reserve (11 goats km⁻²). Simi-
866 larly, Escós et al. (1994) reported an adult survival
867 rate of >0.92, a young survival of 0.49, a breeding

868 success of 0.38, and an annual growth rate of 1.05
869 in the Sierra Nevada National Park (2 goats km⁻²).

870 In general, mortality due to predation appears
871 to be low: predation by golden eagle and red fox
872 *Vulpes vulpes* has been reported only occasionally
873 (Fandos 1991). Large predators such as wolf
874 *Canis lupus* are absent in most of the species'
875 range. Mortality caused by legal and illegal hunt-
876 ing is the main limiting factor, at least in
877 populations not affected by diseases. Typically,
878 game hunting focuses on specific age and sex
879 classes (old males are preferred) which can alter
880 the population structure. The selective removal of
881 large-horned animals might contribute to a
882 decrease in horn size in the population (Pérez
883 et al. 2011). Hunting bags have increased signif-
884 icantly in the last decade, and, currently, the num-
885 ber of Iberian wild goats that are hunted each year
886 is over 11,000 (Garrido et al. 2019); however,
887 detailed information on the regulatory effects of
888 hunting on Iberian wild goat population dynamics
889 is missing.

890 Over the recent years, most populations
891 showed an increasing trend. New populations
892 have been established thanks to translocations
893 (Moço et al. 2006; Refoyo et al. 2014), but most
894 of the growth, both demographic and geographic,
895 has occurred through natural expansions (Lucas
896 et al. 2016). Other populations have merged, cre-
897 ating a very dynamic situation of subpopulations
898 as part of metapopulations. Sarcoptic mange has a
899 high demographic impact, with sporadic out-
900 breaks with mortality rates around 20% and
901 extreme outbreaks with mortality rates up to
902 81%, as in Cazorla at the end of the 1980s (Fandos
903 1991; León-Vizcaíno et al. 1999).

904 Intra- and interspecific competition. A mecha-
905 nism to avoid competition for resources is asyn-
906 chrony between age-class groups in the daily
907 activity patterns of Iberian wild goat (Alados and
908 Escós 1987). Interspecific relationships with phy-
909 thophagous insects, better described as amensalism
910 or predation rather than as pure competition,
911 reduce insect abundance (Zamora and Gómez
912 1993; Gómez and González-Megías 2002).
913 Besides, there is overlap with the (macro) ecolog-
914 ical requirements of native, but reintroduced, red
915 deer (Acevedo and Cassinello 2009b), exotic

916 aoudad *Ammotragus lervia* (Acevedo et al. 916
2007b), and domestic goats (Acevedo et al. 917
2007a), showing a high potential of these species 918
to interact with wild goat. One Pyrenean popula- 919
tion lives in sympatry with feral goats (>900 indi- 920
viduals) (Herrero et al. 2013a, b), an anomalous 921
situation that should be monitored closely and 922
managed to prevent competition and hybridization. 923

924 Global change. Species distribution modeling
925 suggests that species environmental suitability
926 would increase in the near future (Real et al. 926
2013). The effects of changes in land use (mainly 927
related with renaturalization processes, i.e., from 928
cultures to woodlands) on the species' distribution 929
might increase the species' range and abundance 930
in Andalusia (Acevedo et al. 2011b). At a local 931
scale, demographic data indicated increases in the 932
species' range and population size in recent 933
decades, which is expected to continue in the 934
future years (Cano-Manuel et al. 2010, González 935
et al. 2013). Such an increase can be also attrib- 936
uted, at least partly, to changes in land use. In 937
general, the species' population size and range 938
has expanded and the process continues now- 939
days (Lucas et al. 2016). Currently, the densities 940
of some populations suggest the need for popula- 941
tion control or hunting, rather than restocking, 942
because negative effects of population over- 943
abundance have been reported (Perea et al. 944
2015). In the future, however, stochastic events 945
and prolonged droughts might have significant 946
effects on population dynamics, mainly due to 947
reduction in availability of food resources, emer- 948
gence of new pathogens, alterations in phenology, 949
etc. (Cano-Manuel et al. 2010). 950

951 Conservation Status

952 Iberian wild goat is listed in Appendix III of the 952
Bern Convention and in Annex V of the EU Hab- 953
itats and Species Directive. *C. p. victoriae* occurs 954
in the Central Mountain Range, Cantabrian 955
Mountains, and the Pyrenees. *C. p. hispanica* 956
occurs in Southern and Eastern Iberia. The species 957
occurs in a number of protected areas; however, 958
most of the species range is outside of protected 959
areas. 960

961 The IUCN lists Iberian wild goat as Least
 962 Concern (LC) (Herrero and Pérez 2018). The spe-
 963 cies is abundant, and its range and population
 964 have expanded because of numerous important
 965 socioeconomic changes such as law enforcement,
 966 rural abandonment, and translocations
 967 (reintroductions, conservation introductions, rein-
 968 forcements). Game Reserves and protected areas
 969 have played a crucial role in favoring the species'
 970 recovery (Pita Fernández et al. 2008).

971 Management

972 Early conservation and outbreaks. Management
 973 has influenced the contemporary history of Ibe-
 974 rian wild goat, which began with a conservation
 975 program in 1905 to preserve the remaining
 976 populations (Alados 1997). Hunting regulations
 977 and changes in land use have helped improving
 978 the conservation status of the species in the last
 979 decades of the twentieth century (e.g., Fandos
 980 et al. 2010; Acevedo et al. 2011b). At the end of
 981 the twentieth century, some mange outbreaks
 982 occurred (see “Population Dynamics” section)
 983 and regions implemented management programs
 984 for the species. The aim was to preserve some
 985 isolated populations, and perception of sarcoptic
 986 mange as the main threat promoted some pro-
 987 grams aimed at improving the control of this dis-
 988 ease at the population level. For instance, in
 989 Andalusia, a regional strategy for the conservation
 990 of the species includes a monitoring program (dis-
 991 tribution and abundance) and a reference regional
 992 field station of Iberian wild goat. The latter con-
 993 sists in an enclosure for maintaining a small pop-
 994 ulation, intensively monitored at the population
 995 and health levels. Habitat management, mainly
 996 consisting in the creation of pastures and in the
 997 elimination of shrubs, occurs in some of those
 998 enclosures and public Game Reserves (Pita
 999 Fernández et al. 2013). Animal translocations are
 1000 an extensively used management practice, either
 1001 to reintroduce the species in areas where it had
 1002 been extirpated or, lately, to remove animals in
 1003 order to control population size and minimize
 1004 negative effects of overabundance.

1005 Translocations and escapes. Since the nine-
 1006 teenth century, Iberian wild goat has been trans-
 1007 located to formerly occupied areas as well as to
 1008 new areas (e.g., Pérez et al. 2002; Acevedo and
 1009 Cassinello 2009a; Prada and Herrero 2011; see
 1010 also Fig. 2). It is remarkable that a limited number
 1011 of populations have acted as sources for the
 1012 reintroduction programs (see also “Current Distri-
 1013 bution” section). In the twentieth century,
 1014 unintentional escapes from enclosures (Moço
 1015 et al. 2006; Herrero et al. 2013b) or the deliberate
 1016 creation of new populations (Peral 1993; Refoyo
 1017 et al. 2014) have occurred. Administrations and
 1018 hunters promoted translocations mainly for hunt-
 1019 ing purposes. The genetic characteristics of most
 1020 of the populations are not well-known (but see
 1021 Manceau et al. 1999), and understanding the
 1022 impact of these translocations is important for
 1023 assessing the genetic status of the species. For
 1024 instance, all current *C. p. victoriae* populations
 1025 come from individuals from the Sierra de Gredos
 1026 population, which experienced a strong bottle-
 1027 neck at the end of the twentieth century (Acevedo
 1028 and Cassinello 2009a; Prada and Herrero 2011).
 1029 Extreme population declines might increase the
 1030 loss of genetic variability, which has already
 1031 occurred in some source populations.

1032 Trophy hunting. The history of the conserva-
 1033 tion and management of the Iberian wild goat, an
 1034 exclusively Spanish hunting trophy for more than
 1035 a century, has been largely affected by trophy
 1036 hunting during the twentieth century. For
 1037 instance, trophy hunting stopped the efforts to
 1038 recover the Pyrenean subspecies, which once
 1039 occupied the entire Pyrenees (García-González
 1040 and Herrero 1999). The fact of considering *C. p.*
 1041 *pyrenaica* a subspecies rather than a species (as it
 1042 was defined, originally, in the nineteenth century)
 1043 also reduced the recovery efforts (Gippoliti et al.
 1044 2018). In many rural areas in Spain, Iberian wild
 1045 goat is an important public and private economic
 1046 resource, and Spain is the only country that allows
 1047 hunting, while the species is protected in France
 1048 and Portugal. In Spain, Iberian wild goat manage-
 1049 ment is mainly based on trophy hunt, although
 1050 culling has become more common in some
 1051 populations.

1052 Overabundance. Damage control is one of the
 1053 key aspects of Iberian wild goat management,
 1054 even if scientific information is not available and
 1055 technical information is limited. Given the recent
 1056 numerical increase of goat populations, manage-
 1057 ment strategies should be adapted to a very differ-
 1058 ent scenario in which the species has become
 1059 overabundant, with subsequent damages to
 1060 human activities (e.g., agriculture, natural envi-
 1061 ronments, car accidents). Perea et al. (2015)
 1062 examined woody vegetation to assess the ecologi-
 1063 cal sustainability 25 years after the species
 1064 reintroduction to the Sierra de Guadarrama.
 1065 Almost one quarter of the woody species
 1066 exhibited unsustainable levels of browsing, with
 1067 a low level of natural regeneration; a 50% reduc-
 1068 tion in current population density (i.e., 47 goats
 1069 km⁻²) is needed to increase the probability of
 1070 successful regeneration to nearly 60%. In
 1071 fragmented habitats that have agricultural land
 1072 near shelter areas (Lucas et al. 2016), Iberian
 1073 wild goats tend to feed mainly on cereal crops,
 1074 almond trees *Prunus dulcis*, and olive trees *Olea*
 1075 *europaea*. Such conflicts influence hunting quotas
 1076 and thus hunting pressure in those areas. Popula-
 1077 tion trends in most nuclei suggest that quotas are
 1078 insufficient to regulate populations, and, conse-
 1079 quently, an increase of damages caused by wild
 1080 goat is expected (e.g., Escós et al. 2008; Marco
 1081 et al. 2011). However, culling is currently under-
 1082 taken to decrease population densities and avoid
 1083 the undesirable effects of overabundant
 1084 populations (e.g., Refoyo et al. 2014).

1085 Future Challenges for Research 1086 and Management

1087 The Iberian wild goat has experienced an incred-
 1088 ible expansion in range and abundance over the
 1089 last 30 years, which has changed its conservation
 1090 status and, accordingly, conservation and man-
 1091 agement needs. Consequently, the research, con-
 1092 servation, and management priorities should be as
 1093 follows:

- Characterize the genetics of all populations; this will help sound decision-making aimed at increasing genetic diversity and/or at prioritizing local adaptations. Future studies should be based on large sample sizes from all populations and should be combined with complete genome sequencing: this will provide a much clearer understanding of the taxonomy and phylogeography of Iberian wild goat.
- A comprehensive revision of the species' taxonomic status that integrates genetic, paleontological, and morphological data. This information will be needed to elucidate the taxonomic status of *C. pyrenaica*.
- Monitor all populations: assessing demography, health, damages (forest, agriculture and car crashes), and biometrics. Special attention should be given to sarcoptic mange, avoiding selective culling of affected animals, which has proved to be expensive and ineffective (Meneguz et al. 1996). Coordinated large-scale monitoring should lead to data-based population management that can meet multiple objectives: increase, decrease, or stabilize populations. Adapt monitoring methods to suit specific habitats and population characteristics.
- Promote autochthonous wild mountain ungulates and prevent the expansion of introduced species with potential to interact with Iberian wild goat, such as mouflon and aoudad.
- Surveys of domestic ungulate health status is a priority because domestic goats probably are the origin of several mange and other disease outbreaks (Cassinello and Acevedo 2007; Astorga-Márquez et al. 2014).
- Eradicate feral goats to avoid issues of hybridization with Iberian wild goat (Moço et al. 2014; Herrero et al. 2013a).
- Studies of the basic biology of the species are lacking for most populations. Dispersal, home range, etc. remain poorly known.
- Evaluate the need or opportunity for further reintroductions and reinforcements in small populations.

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