

Population dynamic of the Spanish ibex *Capra pyrenaica* in Sierra Nevada Natural Park (southern Spain)

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The whole area of distribution of the Spanish ibex *Capra pyrenaica* Schinz, 1838 population of Sierra Nevada Natural Park was surveyed for the first time during July-August 1993 and the densities were estimated by using the line transects method. A mean density of 7.69 ± 0.50 ibexes/km² was obtained, with sex ratio (males/females) of 0.80 and kids/adult females rate of 0.39. Data on size and composition of groups and on altitudinal distribution are also included. The demographic trend of ibexes in Sierra Nevada during last 30 years is reconstructed on the basis of data referred to the National Game Reserve, located within our study area.

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Introduction

Although there still exists certain disagreement with regards to the taxonomic status of the Spanish ibex, because morphological and biometric features (Cabrera 1911) are contrary to preliminary data obtained by starch gel electrophoresis analysis (Nadlinger *et al.* 1992), it is generally considered amongst zoologists and hunters that *Capra pyrenaica* Schinz, 1838 is an Iberian endemic species.

With respect to the ibex of southern Spain, the population from Cazorla, Segura y Las Villas range of mountains is one of the best known (Fandos 1986, 1991). On the contrary, data on the biology and ecology of ibexes from Sierra Nevada are scarce and fragmented; they are restricted to some concrete parts of this area such as the National Game Reserve and a zone measuring 30 km² in eastern Sierra Nevada (Rodríguez 1969, Alados 1985b, Escos 1988, Fandos 1989, 1991, Martínez 1988, 1990). In order to establish an adequate plan of management for this population we have started to study it in its entirety, beginning at the demographic level.

Study area

The survey of density of *Capra pyrenaica* was carried out in the Sierra Nevada Natural Park, which has an extent of 1690 km² and comprises the alpine massif with the highest peak of the Iberian Peninsula, the Mulhacén (3481 m) and eleven more peaks higher than 3000 m. Because of its latitudinal position (37°N) and its proximity to the Mediterranean sea, Sierra Nevada shows a mediterranean climate with important altitudinal gradients of temperature and rainfall, all the bioclimatic stages described for this climate being present. Much of the natural vegetation of these mountains has been continuously altered by human activities so as to become relict. Nevertheless the flora of Sierra Nevada is still rich, comprising over 2000 species of plants with a high number of endemic species amongst them (Valle 1985).

Figure 1 shows the geographic location of Sierra Nevada Natural Park, and delimits the National Game Reserve, a 354 km² area protected since 1968.

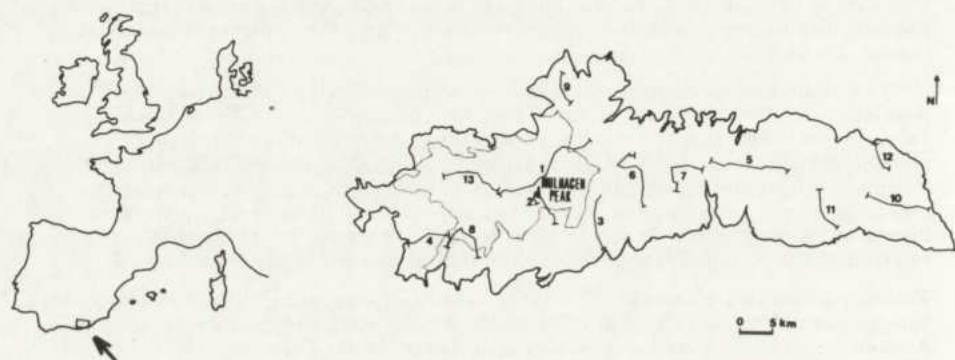


Fig. 1. Geographical location of the Sierra Nevada Natural Park in southern Spain and location of transects sampled within the Sierra Nevada Natural Park. Discontinuous line indicates the limit of the National Game Reserve.

Material and methods

Survey was carried out during July and August 1993, by means of the line transects method (Anderson *et al.* 1979, Burnham *et al.* 1980, Buckland *et al.* 1993). Thirteen transects (Fig. 1), with a total length of 135.2 km and ranging from 400 to 3484 m in altitude were walked by two-three persons at a mean speed of 1.5 km/h, between 07.00 am and 09.00 pm. Perpendicular distances of animals observed to the line transect were grouped into 50 m intervals for statistical treatment of data, which was carried out by means of the program DISTANCE (Laake *et al.* 1993). For density estimation the Fourier Series estimator was selected.

Sex and age of each animal observed were recorded too. The demographic trend of the ibex population in the National Game Reserve was obtained on the basis of available data from scientific papers and official censuses from the area.

Results

A total of 415 ibexes were observed during the census period and data on perpendicular distances were compared to those theoretical ones provided by the model by means of χ^2 -test.

Table 1. Age classes within male *Capra pyrenaica* (yearlings are omitted).

Age classes		Number (%)	
Youngs:	1-2 yr	36	(23.2)
Subadults:	3-4 yr	73	(47.1)
Adults:	5-6 yr	22	(14.2)
	7-8 yr	10	(6.5)
Olds:	> 8 yr	14	(9.0)
Total		155	(100.0)

Table 2. Frequencies of different kinds of groups of *Capra pyrenaica*.

Kind of group	Number of observations	Percentage
Single individuals	22	26.8
Youngs	0	0.0
Males	12	14.6
Females	11	13.4
Females with kids	31	37.9
Mixed groups	6	7.3
Total	82	100.0

A density of 7.69 ± 0.50 ibexes/km² was obtained, with a variation coefficient of 6.4%. Thus, we have a total population of about 13000 ibexes in the Sierra Nevada Natural Park (95% confidence interval: 11370-14660).

With regards to sex, 155 males older than 1 year and 192 females, of which 175 were adult, were observed. Only 69 yearlings were detected. Thus, we have a sex ratio (males/females) of 0.8 and a reproductive index (kids/adult females) of 0.39. An age pyramid for males was obtained as included in Table 1.

During this study a total number of 82 observations, both with single individuals and groups were made (Table 2). Groups size ranged from 2 to 33 animals, with a mean value of 7 ibexes/group. Generally, groups of males were greater than the remaining kinds of groups. Nevertheless groups of females with kids were the most frequently observed. According to the altitudinal distribution over 95% of ibexes were observed in altitudes over 2000 m (Table 3), mainly in the highest peaks and surrounding areas, which are located within the National Game Reserve. Transects number 1, 2, 8 and 13 are located within this area. When

Table 3. Altitudinal distribution of *Capra pyrenaica* specimens observed in Sierra Nevada during survey.

Altitudinal range (m)	Length (km)	n of ibexes	% (n = 415)	inds/km
500-750	1.6	0	0	0
750-1000	7.2	0	0	0
1000-1250	12.2	4	0.9	0.3
1250-1500	5.3	0	0	0
1500-1750	5.2	0	0	0
1750-2000	14.4	9	2.2	0.6
2000-2250	21.2	20	4.8	0.9
2250-2500	34.5	88	21.2	2.6
2500-2750	10.7	44	10.6	4.1
2750-3000	6.1	90	21.7	14.7
3000-3250	14.8	111	26.7	7.5
3250-3481	2.0	49	11.8	24.5

we grouped data from these transects we obtained a density of 20.6 ibexes/km² (ES = 1.91, CV = 9.3%, 95% confidence interval: 16.9–24.4 ibexes/km²). In the reserve the number of animals recorded reached almost 80% of the total observed. Since 1960 the population in this area has been continuously increasing, rising densities over 20 ibexes/km² in 1993. This growth curves fit to the function $DEN = B [EXP(A \times t)]$, where DEN means density, B and A are parameters of the function ($A = 0.1017$, $B = -199.8$), and t is the time in years.

Discussion

The summer is the best and, in the practice, the only season in which the whole ibex population of Sierra Nevada can be censused because the absence of snow allows accesibility to all areas of this Natural Park simultaneously. Moreover, during other seasons a large number of ibexes descend to lowland areas (forested zones) where visibility is considerably less. The use of other census methods here, such as the pellet group technique, would decrease the accuracy of results because of the presence of domestic sheep and goats and the similarity of their pellets and to those of ibexes.

The unpredictable variations of climate and availability of food, typical of the mediterranean climate, involve a high risk that females will be barren as well as a heavy mortality of mothers, embryos and kids (Alados and Escos 1985, Fandos 1989). The proportion of females with kids observed during this study seems to be too small, if we take into account a fecundity rate of 0.83 for this species (Fandos 1991). The value observed in our study might be considered as a measure of reproductive success and agrees with data given by Alados and Escos (1985) and Fandos (1986) just before the decline of the ibex population in Cazorla range (southern Spain).

Size and structure of groups were similar to those shown by other Spanish ibex populations at this time of year (González 1982, Alados 1985a, Fandos 1991). With regards to the altitudinal distribution, it seems to be influenced by the presence of fresh pastures in the highest peaks area during the summer.

We must take into account the altitudinal seasonal movements of ibexes which can produce relevant fluctuations in local density. Other factors, like human pressure (Escos 1988) or competition with domestic sheep (Martinez 1990) also have an influence on ibexes distribution and density at particular locations. Nevertheless, when we consider the data overall they become statistically consistent and more realistic.

The population of Spanish ibex in Sierra Nevada was dwindling in 1936 (Alados 1985b), although its size has been continuously increasing since the creation of the National Game Reserve. The absence of predators, inadequate management of the species, together with the decrease of furtive hunting seem to be the causes for the actual status of this ungulate in this natural park. Since a population can

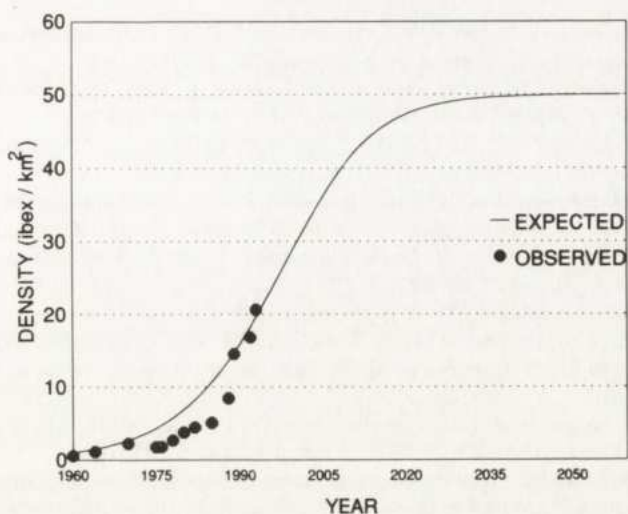


Fig. 2. Demographic trend of *Capra pyrenaica* in the Sierra Nevada Natural Park during last decades and future density values expected.

not be increasing indefinitely, when we fit the trend of ibexes population in Sierra Nevada with its actual growth rate $r = 0.102$ and a theoretical asymptote of 50 ibexes/km² (Fig. 2) we obtain that about yr 2010 this value would be reached. The expected density value, given by this logistic model for 1993 is 19.6, which is similar to that obtained in this study. At present density is similar to that observed in the Cazorla Range Mountains before an outbreak of sarcoptic mange produced over 75% of mortality of ibexes. Because the population is still rising and scabiosis cases have started to be observed, natality is low and there are high densities of domestic ungulates (Agencia de Medio Ambiente 1993) that exert a strong feeding competence with the ibex (Martínez 1988), we guess that this population is in a previous step to a high mortality process. Time will confirm it.

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