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## Estimating mountain ungulate density
## in Sierras de Cazorla y Segura

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The mountain ungulates presents a challenge for wildlife ecologists because
of the rugged terrain inhabited by the species. Accordingly, we still lack a censu-
sing method that is quick, does not require the participation of a large number
of persons and, at the same time, is sufficiently accurate.

The topographical features of the habitat have their advantages, such as
the availability of natural observation points overlooking the animal range, which
allow the observer to record more easily and precisely the relative positions of,
and the distances between, the various animals in a group. But due to the high
vegetation density in our study area in the Sierras de Cazorla y Segura in Southern
Spain, it is desirable to add other complementary method, which is commonly
used in ungulate research (Schultz and Muncy 1957 ; Teer *et al.* 1965 ; Hirst
1969 ; Hemingway 1971 ; Eltringham 1973 ; Zejda 1984) and it has been described
by Burnham *et al.* (1980).

At the present, no census using direct methods has been used to determine
the density of the ungulates in the Sierras de Cazorla y Segura. We need a
censusing method that will show the relative abundance of four of the species
of wild ungulates living together in the area. These are *Capra pyrenaica, Dama*

*dama, Cervus elaphus,* and *Ovis ammon.* In order to do that we have devised two censusing methods. First, all animals sighted from both sides of a car travelling along a transect are censused. The second method was designed to emphasize the topographical features of the range such as was described by Nievergelt for the ibexes in Africa (Nievergelt 1981).

## METHODS

*Study area.*

The study area, totalling 663,67 km², lies in the southeast of Spain between latitudes 37°45' and 38°10'N and longitudes 2°40' and 3°00'W. These rugged and steep mountain terrain are limestone and the altitude oscillate between 500 and 2100 m. Most part of the reserve has been afforested with *Pinus nigra, P. pinaster* and *P. halepensis,* which, together with *Quercus ilex,* are the main tree species present. The region is crossed by a dense road network with varying traffic intensity.

*Data recorded.*

The data were recorded by two observers and two different census methods were used. Both were carried out simultaneously during the rut period of the four species concerned *(Capra pyrenaica, Dama dama, Cervus elaphus, Ovis ammon)* so that both sexes would be equally visible.

Data collected from 8 September to 10 January at dawn and dusk for one week each month. A total of 160 hours were spent in observation.

Census method on foot were excluded, because of the more fast detection of the observer by the animals studied. For the census from the road, 47 transects were used totalling 325 km. The areas selected were geographically separated and they were representative of the habitat of the animals studied. The curves were not considered in the longitudinal measures of the transect. The width of the strip viewed varied with the transect with a maximum of 350 m. 413 animals of different species were sighted comprising 125 Spanish ibex, 133 fallow deer, 133 red deer and 22 mouflons.

Observations were made from 39 fixed points chosen for their good visibility, each being visited 3 to 5 times. The total area covered from these fixed points was 79.3 km² and the number of animals observed totalled 498 made up of 360 Spanish ibex, 39 fallow deer, 70 red deer and 19 mouflons.

Searches for groups of these species were made by 2 observers on either side of the road from a passing car, whose speed did not exceed 20 km per hour. For a closer identification of sighted individuals, each observer used a pair of binoculars (10 × 50). When either observer saw some group, the car stopped and the following records taken : perpendicular distance from road measured with a range finder, size of the group and certain features of the habitat, such as vegetation density, dominant plant species, altitude and topographical peculiarities. An animal was defined as being associated with a group if it was within 100 m of its nearest neighbour.

We signes the fixed points in the course of the transect country. When we reached one of them, we stopped and twice carefully searches the surrounding

area. When a group was detected, we collected same data as those recorded in the transect method.

Each transect was covered only once each month when the weather conditions were good and we tried to record each individual or group only once.

TABLE 1. — Comparative density per km² of different areas observed by transects (1) and fixed points (2).

| Road transects | Spanish ibex | | Red deer | | Fallow deer | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 1 | 2 | 1 | 2 |
| Gilillo | 5.54 | 9.24 | 0 | 0 | 0.53 | 0.76 |
| Gualay | 5.54 | 25.36 | 0 | 0.49 | 8.29 | 5.46 |
| La Hoya | 2.49 | 0.43 | 10.08 | 0.37 | 0 | 0 |
| La Mesa | 1.66 | 3.26 | 0.77 | 0 | 6.68 | 0 |
| Mirabueno | 5.54 | 2.75 | 52.35 | 3.25 | 0 | 0 |
| Valdeazores-N.S. Pedro | 1.11 | 9.94 | 0.39 | 0 | 0.53 | 0 |
| Vado carretas | 2.22 | 8.57 | 0 | 0 | 3.48 | 5.58 |
| Valdecuevas | 0.28 | 4.76 | 0.39 | 0 | 1.34 | 1.28 |
| P. Herrerías-Cañada | 9.41 | 44.16 | 0 | 0 | 6.68 | 2.7 |

*Data analyses.*

We used a estimation procedure based on a Fourier series expansion of the probability density function considering each group as unit to analyse the road transect data. It is the method considered more robust and its efficiency is good (Burnham *et al.* 1980, 1985).

For the analyses of data collected from fixed points, we followed partially to Nievergelt (1981). Factors that reduce visibility are long distances, unfavourable direction of the slope, certain topographical features and dense vegetation cover. Relative visibility was estimated using sets of aerial photographs, as well as personal observations in the area concerned. Because the vegetation cover changes little over the seasons, due to the evergreen vegetation, the same estimated values were used for the whole year. The distribution pattern of these visibility values was considered to correspond with the pattern of these visibility values was considered to correspond with the pattern of the observed numbers of a radomly distributed animal, such as Nievergelt (1981). We consider each individual as unit to analyse these data. Each fixed point was classified from 0 to 5 considering the vegetation cover, 0 correspond to 100 % of visibility and 5 correspond to 0 % ; for this analyses we took into account only areas with visibilities from one of the observation points greater than 20 %.

The increase over the planar area due to the slope of the terrain was calculated by weighing a piece of tracing paper equal to the area traced from an aerial photograph and the height indicated by the contour lines.

RESULTS AND DISCUSSION

The results of road transects were compared with those from fixed-point surveys for Spanish ibex, reed deer and fallow deer. Methods are significantly correlated for Spanish ibex ($r = 0.586$, df = 7, $P < 0.025$) and for red deer ($r = 0.963$, df = 4, $P < 0.001$) but not for fallow deer ($r = 0.055$, df = 5, N.S.) (Table 1).

The road transect method gave the higher number for red deer but the lower number for Spanish ibex, probably it is caused of the different habitat of both species. Assuming we saw fewer individuals than were really present, due to their cryptic colour, we consider that the method that maximizes the animal density is the more suitable. This is the fixed point survey for Spanish ibex and the road transect for red deer.

The tendency to record more Spanish ibex from fixed point surveys may be due to the preference of this species for high altitudes with steep slopes, where roads are not frequent, but where it is easy to make observations from fixed points. The preference of red deer for a flatter terrain with dense vegetation makes it more difficult to census this species from fixed points.

The mean density of Spanish ibex is $3.65$ km² according to the transect method and $11.11$ km² by the fixed point method. The corresponding figures to red deer are $7.26$ km² and $1.78$ km² respectively. Fallow deer and mouflon are more scaterred, with a mean densities of $2.55$ from transects and $1.49$ km² from fixed points for fallow deer and $0.38$ km² from transects and $0.60$ km² from fixed points for mouflon. Due to the higher hunting pressure on fallow deer in the last years, the population density estimated is probably lower than the real one, because of their frightened behaviour.

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