

A COMPARISON OF THE DIETS OF THE WILD GOAT (*Capra pyrenaica*),
DOMESTIC GOAT (*Capra hircus*), MOUFLON (*Ovis musimon*)
AND DOMESTIC SHEEP (*Ovis aries*)
IN THE CAZORLA MOUNTAIN RANGE

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SUMMARY

Autumn diet comparisons of four sympatric Caprini species inhabiting an area of 2 km² in Sierra de Cazorla (Jaen, Spain) have been carried out. Diet was estimated by micrographic analysis of fresh faeces of four herbivores: Spanish wild goat (Capra pyrenaica), domestic goat (Capra hircus), Corsican moufflon (Ovis musimon) and domestic sheep (Ovis aries). Available plant food measurements and animal censuses in the study area were also carried out. Diet selection was different in the four species. Domestic goat fed predominantly on evergreen oak (Quercus ilex) (81%). Half of the sheep's diet (48%) was composed of graminoids, but a quarter was dwarf shrub Helianthemum sp. (25%). Wild goats selected a mixed diet of 41% ligneous plants (16% evergreen oak), 14% graminoids and 45% herbaceous plants (29% monocotyledoneous bulbous species). Moufflon was the species that grazed most and it selected strongly in favour of monocotyledoneous herbs (80%).

Our results agree well with the hypothesis attributing browsing food habits to Capra genus and grazing habits to Ovis genus. They are less concordant with the other tested hypothesis that domestication leads to generalistic feeding habits.

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RESUMEN

Se compara el régimen alimentario de cuatro especies de rumiantes, pertenecientes a la tribu Caprini, que coexisten en pastoreo en una zona de 2 km² de la Sierra de Cazorla (Jaén, España). Para ello analizamos los excrementos de las distintas especies: cabra montés (Capra pyrenaica), cabra doméstica (Capra hircus), muflón (Ovis musimon) y oveja (Ovis aries) recogidas en otoño en 1988. Además se tomaron datos de la vegetación disponible y se hicieron censos del área de estudio. Desde el punto de vista de la dieta seleccionada, es de destacar que la cabra doméstica consume un 81% de encina. La oveja es menos pastadora de lo que cabría esperar, con un consumo de 25% de Helianthemum sp. y un 48% de gramíneas. La cabra montés selecciona una dieta mixta de 41% de plantas leñosas (16% de encina), 14% gramíneas y 45% de otras herbáceas (29% de especies monocotiledóneas bulbosas). El muflón es la especie más pastadora y selecciona fuertemente las monocotiledóneas herbáceas (80%).

Nuestros resultados son concordantes con la hipótesis planteada en el sentido de atribuir hábitos ramoneadores a las especies del género Capra y hábitos pastadores a las especies del género Ovis. Pero no son muy concordantes con respecto a la hipótesis en la que se plantea que los animales domésticos son menos discriminadores frente al alimento que los animales salvaje.

INTRODUCTION

Sheep and goats have been traditional users of the vegetable resources of Mediterranean mountains. However, little is known about the trophic strategies they adopt when they have to compete with one another for those same resources, nor the repercussion that these have on the vegetation. Four Caprini species which are filogenetically close (Capra pyrenaica, Capra hircus, Ovis musimon and Ovis aries), coexist at pasture in several points of the Cazorla and Segura mountain ranges. The two wild species (Capra pyrenaica and Ovis musimon) diverged as a result of natural selection some 5 million years ago. The domestic species, moreover, have undergone the selection imposed on them by man. Despite their kinship relation, one of the most remarkable intergeneric differences concerns their trophic ecology. The Capra species are considered browse eaters while the Ovis species are considered more grazers (Van Dyne et al. 1989). Furthermore, some authors (Schwarz and Ellis, 1981) suggest that domestication may lead to generalism, making the animals discriminate less between foods.

The general aim of our research will be to determine the influence of the evolutionary history of the Caprini tribe on its trophic strategies. This work seeks to make the first contribution to this topic, contrasting the two previous hypotheses (intergeneric differences and the effect of domestication) in a concrete situation: the four species can be found simultaneously in a reduced area of 2 km² in the Sierra de Cazorla (Jaén) in free grazing. The chosen time of year is autumn, when the summer drought imposes certain restrictions on resources, and the theoretical chances of competition are higher.

METHODS

Area of study

This study was carried out in the Natural Park of the Cazorla, Segura and Las Villas mountain ranges which covers a total extension of 214.000 ha. It lies at the easternmost point of the province of Jaen, between 37° 45' and 38° 10' latitude and 2° 40' and 3° 00' longitude.

Geologic substratum is predominantly calcareous. Annual rainfall varies between 550-600 mms on the plains and 1400 mms at higher levels. Above 1500 m it freezes, and in summer the temperatures exceed 40 °C. The area of the study covers 2 km² at an altitude of 1300 m. The vegetation is typically Mediterranean and can be fitted into the basophylous supramediterranean series of the Betican region (Valle et al. 1989). Main plant species are: Quercus rotundifolia in the arboreal stratum and Berberis hispanica, Crataegus monogyna, Rosa canina, Juniperus oxycedrus, Daphne gnidium, Cytisus reverchonii, Geum sylvaticum, Piptatherum paradoxum, - among others- in the shrub and ground level. Forestry in the past has favoured the presence of Pinus nigra.

In the area of this study both wild herbivorous (Capra pyrenaica, Ovis musimon, Dama dama, Cervus elaphus) and domestic animals (Capra hircus and Ovis aries) coexist.

Vegetation sample

To obtain an estimate of the available vegetation in the study area two techniques were used, as no single ideal method exists to measure both the herbaceous and the ligneous vegetation. The herbaceous and low shrub stratum (<30 cm.) was determined by means of four fixed transects, recording the plant species in contact with the toe of the observer's boot at intervals of every 5 strides (Dunbar, 1978). The length of the transects was proportional to the surface area of the principal habitats in the study area. A total of 400 contacts were made.

The availability of ligneous vegetation (30-150 cm) was estimated by means of determining plant species cover in 78 plots of 5 m² along the aforementioned transects. The previous specific frequencies obtained in each stratum were weighted against the relative importance of the total vegetation at the corresponding level and they were added together (Kasworm et al. 1984). The identification of doubtful taxa was carried out in the Botanical Department of the E.E.Z.A. and Herbario Jaca (I.P.E.).

Dietary analysis

The diets were determined from mixtures of faeces of 10 mountain goats, 10 moufflons, 9 domestic goats and 5 sheep, collected between the second fortnight in September and the first fortnight in October 1988. Micrographic technique according to Garcia-Gonzalez (1984) was used for the faecal analysis. A reference collection of the epidermis of the main plant species in the study area had previously been prepared. Between 400-500 epidermic identifications were made per animal species, with a

total of 2060 fragments. For the purpose of presenting the results the vegetal species have been placed into four categories: ligneous (shrubs and trees), dicotiledoneous forbs, graminoids (grasses and sedges) and non graminoids monocotiledons (Liliiflorae Order fundamentally)

Abundance of animals

Censuses were carried on by means of a combination of fixed observation points and systematic suveys. The census of the study area was taken on the 13th and 14th of September 1988. Only the census which registered the greatest number of individuals was withheld. The results was: 11 mountain goats, 71 domestic goats, 9 moufflons and 540 sheep. These results were notably similar to those obtained in July. The density in the zone is of 330.5 animals/km² without taking the cervids into account. The wild species may be considered relatively stable in the study area, at least during this period of research. The mountain goat in the Cazorla Natural Park has an average annual home range of 0.6 km², established by telemetry (J. Escos, pers.comm.). The domestic animals were grazing freely with little human attention.

Dietary comparisons

Dietary comparisons between the different animal species and of the diets with respect to the available vegetation, was made using Kulczynski's similarity index (ISK):

$$ISK = \frac{\sum 2C}{\sum (a+b)} \times 100$$

Where C is the lesser percentage of a common plant species or taxon in the diets. $\sum (a+b)$ is the sum of percentages of all the species in the two diets. The index indicates the percentage of diet which is identical in both animal species, and it oscillates between 0 and 100%.

RESULTS

Results of the faecal analysis and of the samples of vegetation are showed in tables 1 and 2 respectively. The results of the diet per animal species and available vegetation are summarized in figure 1 according to three large categories (shrubs, graminoids and forbs). The unidentified dicotiledons have been included with the forbs, as the epidermis of the ligneous species were well known. The non-graminoids monocotiledons (Liliiflorae) were also included with the herbaceous vegetation. Values of the similarity index between diets are indicated in table 3. The category of unidentified plants has not been computed, except in the case of the Liliiflorae, as the epidermal analysis reveals that this category is composed of only a few identical taxa (Aphyllantes, Crocus, Merendera and Colchicum) in the four diets.

SHRUBS AND TREES	WG	DG	DS	MU
<i>Quercus rotundifolia</i>	16.6	81.4	--	0.2
<i>Pinus nigra</i>	1.9	0.7	1.3	2.6
<i>Quercus faginea</i>	1.2	4.4	--	2.2
<i>Rosa</i> sp	0.3	--	--	--
<i>Juniperus oxycedrus</i>	0.2	--	--	--
<i>Juniperus phoenicea</i>	0.2	--	--	0.2
<i>Ononis aragonensis</i>	--	--	0.2	--
<i>Helianthemum</i> sp	19.2	0.5	25.6	1.4
<i>Cytisus reverchonii</i>	0.5	3.4	8.9	1.2
<i>Thymus mastichina</i>	0.5	--	--	--
<i>Erinacea anthyllis</i>	0.3	--	--	--
<i>Thymus zygis</i>	0.2	--	0.9	--
<i>Hormathophylla spinosa</i>	--	--	0.6	--
Total	41.1	90.4	37.5	7.8
DICOTILEDONEOUS FORBS				
<i>Scabiosa turolensis</i>	0.7	--	0.7	--
<i>Geum sylvaticum</i>	0.2	--	0.2	--
<i>Cerastium boissieri</i>	--	--	0.7	--
<i>Armeria</i> sp	--	--	0.2	--
<i>Alyssum minus</i>	--	--	0.4	--
Total	0.9	--	2.2	--
UNIDENTIFIED DICOTILEDONS				
Total	14.9	6.7	5.2	11.5
GRAMINOIDS				
<i>Brachypodium phoenicoides</i>	3.4	0.5	9.8	8.3
<i>Festuca rubra</i>	1.4	0.7	11.9	2.8
<i>Carex</i> sp	1.2	0.5	2.0	2.8
<i>Brachypodium retusum</i>	1.0	--	0.2	0.8
<i>Piptatherum paradoxum</i>	0.8	--	0.4	1.4
<i>Helictotrichon filifolium</i>	0.3	--	9.4	0.4
<i>Vulpia myuros</i>	0.2	0.2	0.6	--
<i>Brachypodium sylvaticum</i>	--	--	0.2	--
<i>Bromus madritensis</i>	--	--	--	0.2
<i>Festuca hystrix</i>	--	--	0.2	--
<i>Koeleria vallesiana</i>	--	--	--	0.2
<i>Stipa</i> sp	--	--	0.4	--
<i>Vulpia bromoides</i>	--	--	--	1.2
Unidentified	5.4	0.5	3.9	10.1
Total	13.7	2.4	49.0	28.2
NON GRAMINOIDS MONOCOTILEDONS				
<i>Liliiflorae</i>	29.5	0.7	6.3	52.2

Table 1. Percentage diet composition of the four herbivores estimated from fecal analysis. WG= wild goat, DG= domestic goat, DS= domestic sheep, MF= mouffon

SHRUBS AND TREES

<i>Quercus rotundifolia</i>	7.6
<i>Berberis hispanica</i>	7.5
<i>Pinus nigra</i>	5.5
<i>Thymus zygis</i>	5.0
<i>Rosa</i> sp.	4.7
<i>Echinopartum boissieri</i>	4.4
<i>Crataegus monogyna</i>	3.0
<i>Satureja montana</i>	2.4
<i>Helianthemum croceum</i>	1.8
<i>Teucrium polium</i>	1.8
<i>Juniperus phoenicea</i>	1.1
<i>Juniperus communis</i>	0.9
<i>Juniperus oxycedrus</i>	0.9
<i>Erinacea anthyllis</i>	0.9
<i>Daphne gnidium</i>	0.9
<i>Phlomis lychnitis</i>	0.9
<i>Rhamnus</i> sp.	0.5
<i>Amelanchier ovalis</i>	0.5
<i>Cytisus reverchonii</i>	0.3
<i>Rubus</i> sp.	0.1
Total	50.7

DICOTILEDONEOUS FORBS

<i>Eryngium campestre</i>	10.0
<i>Cirsium acarna</i>	5.0
<i>Trifolium campestre</i>	2.7
<i>Scabiosa turolensis</i>	2.7
<i>Chondrilla juncea</i>	2.7
<i>Leontodon taraxacoides</i>	1.8
<i>Carlina corymbosa</i>	1.2
<i>Convolvulus</i> sp.	0.9
<i>Catananche caerulea</i>	0.6
<i>Hieracium pilosella</i>	0.6
<i>Lotus</i> sp.	0.6
<i>Astragalus</i> sp.	0.6
<i>Crucianella angustifolia</i>	0.3
<i>Echium</i> sp.	0.3
<i>Petrorhagia nanteuilli</i>	0.3
<i>Ptorilis leptophylla</i>	0.3
Otras	0.3
Total	30.4

GRAMINOIDS

<i>Aegilops ovata</i>	8.6
<i>Brachypodium phoenicoides</i>	2.4
<i>Agrostis tenuis</i>	1.8
<i>Festuca hystrix</i>	1.2
<i>Cynosurus elegans</i>	0.9
<i>Piptatherum paradoxum</i>	0.9
<i>Dactylis glomerata</i>	0.6
<i>Avena</i> sp.	0.3
<i>Carex</i> sp.	0.3
Unidentified graminoids	1.5
Total	18.3

UNIDENTIFIED DICOTILEDONS

Total	0.3
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Tabla 2. Plant species percentages of available vegetation in the study area in September 1988. Frequencies were calculated by weighting canopy coverage and abundance of each species by the proportionate occurrence of total vegetation in the herbaceous and shrub stratum (see text).

WG	CD	MU	DS	
--	21.8	42.7	35.2	WG
	--	7.0	7.1	DG
		--	24.3	MU
			--	DS

Tabla 3. Kulzynski's similarity indices between herbivorous diets. WG: wild goat, DG: domestic goat, DS: domestic sheep, MF: moufflon.

1- Comparison of the diet selected between two genera

The wild goat and the moufflon show the highest index of similarity in their diets (42.7%) (table 3). Both species show a high percentage of consumption of monocotyledons and mainly of bulbous species, and they differ in their consumption of ligneous species (phanerophytes and chamaephytes): the wild goat with 41.1% whereas the moufflon has 7.8% (table 1).

Domestic goat and sheep show one of the lowest indexes of similarity of the ungulates studied (7.1%). Although both consume ligneous species, the domestic goat consumes 81.4% evergreen oak, whereas the sheep consumes 25.6% *Helianthemum* sp. The sheep consumes 49% graminoids species in contrast to only 2.4% in the case of the domestic goat (table 1).

2- Comparison of the diet selected by the same genus

As table 3 shows, the diet selected by the wild goat presents a low index of similarity with that of the domestic goat (21.8%). The high percentage of ligneous species in domestic goat diet (90.4%) in contrast to the wild goat (41.1%) is outstanding. Of the ligneous species domestic goat consumes evergreen oak and *Helianthemum* sp. It is noticeable that the wild goat consumes a high proportion of monocotyledons (43.2%), the majority of which consists of bulbous species (29.5%), unlike the domestic goat which only consumes 3.1% monocotyledons.

The diet selected by the moufflon also shows a low index of similarity with that of the sheep (24.3%). Sheep consumes high percentage of ligneous species (37.5%) compared to the moufflon (7.8%). Of this, the 25.6% are composed by *Helianthemum* sp (table 1). The moufflon consumes 80.4% monocotyledons (52.2% bulbous plants), whereas sheep consumes 55.3% monocotyledons of which only 6.3% are geophytes.

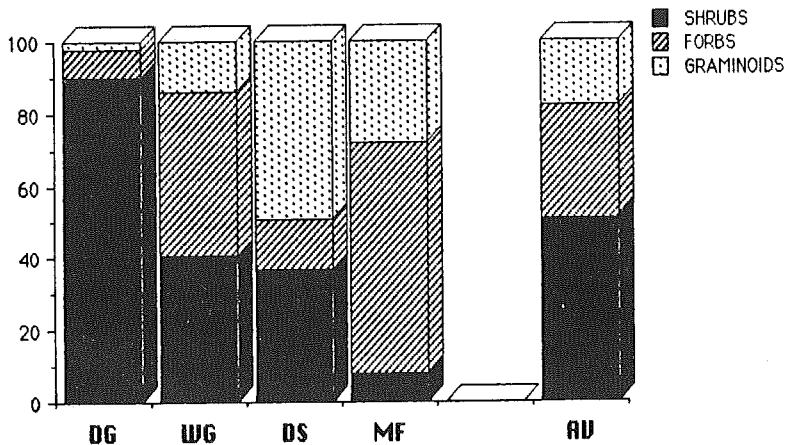


Fig. 1. Percentage of mean food class in the herbivorous diets and in the available vegetation (AV).

3- Comparison between the diets and the available vegetation

The four species of ungulates show a low index of similarity between their diets and the vegetation. The values for the wild goat, domestic goat, moufflon and sheep are 16.5; 9.7; 8.3 and 8.2 respectively. All these values are very low, but the value for the wild goat stands out, being approximately twice as high as the others. In this ruminant the consumption of the three principal types of food is relatively similar to the available vegetation (fig.1), although the proportion of ligneous vegetation is somewhat lower. The main differences in the other species consist of: a high consumption of ligneous vegetation, above all the evergreen oak, for the domestic goat; a high consumption of herbaceous vegetation, especially Liliiflorae, for the moufflon; and a high consumption of graminoids for the sheep. Some vegetal species appear to be strongly selected, as they show up in the dietary analysis but not in the vegetation sample. This is the case of Quercus faginea, Festuca rubra, Helictotrichon filifolium or the Liliiflorae group. Helianthemum sp. also appears to be strongly selected by the sheep and wild goat, whereas other species seems to be clearly ignored: Berberis hispanica, Eryngium campestre, Aegylops ovata etc.

DISCUSSION

The dietary selection each animal species makes depends on factors related to the morphofunctional characteristics of that species and on the available vegetation (Gordon, 1989; Garcia-Gonzalez and Montserrat, 1986). In this study we have attempted to reduce the influence of the vegetation by choosing an area of common grazing, thus increasing the factors which depend on the animal.

The results of this study agree well with those obtained by other authors in the Cazorla range at the same time of the year. Rodriguez and Molera (1985) found 5% ligneous and 95% herbaceous vegetation in moufflons' stomachs. Martinez et al. (1985) found 31% ligneous and 67% herbaceous vegetation in wild goats' stomachs, compared to 41% and 59% respectively in our study. Quercus rotundifolia was also the principal ligneous species in the diet (25%).

From the point of view of the selected diet the four species adopt varying strategies to cover their energy and nutritional needs. The domestic goat seems to be the most selective herbivore, feeding almost exclusively on the evergreen oak (81.4%). The sheep grazes less than would have been expected, with a consumption of 25.6% of Helianthemum sp.; on the other hand it is the species that consumes most grasses and it hardly selects geophytes. The wild goat seems to be less browser than expected, consuming only 16.6% evergreen oak; it shows a preference for the autumn geophytes (Crocus, Merendera, Colchicum, Aphyllantes) among the monocotyledons. The moufflon is the most grazing species, consuming 80.4% monocotyledons and strongly favouring geophytes (52.2%). The high consumption of

Liliiflorae by the two wild species may be brought about by a drop in their toxic level (common in this Order) at the end of the summer.

As far as concerns the two hypotheses set forth in the introduction, our results agree moderately well. The Capra genus is shown to be much more browser than Ovis and this seems to be a major ecological difference between the two genera. This trophic difference is based on the corresponding morphophysiological adaptations, among which is a greater relation of the ruminoreticular volume / live weight in sheep than in goats (Schoonveld et al., 1974), which increases the capacity to better digest fibrous fodder (e.g. dry grasses) (Hanley and Hanley, 1982).

The hypothesis on the effects of domestication (tendency to trophic "generalism"), is less in line with the results obtained in the study, but only depending on the confused sense of generalism and selective concepts. The domestic goat, for example, is shown to be very "selective" (81% evergreen oak). However, in a general perspective, it may be that domestic animals are less able to discriminate between foods in relation to their ancestors. Sheep have a much greater ruminal capacity than moufflons of the same body weight (García-Gonzalez, 1987). Their stomach is better equipped for eating fodder that is high in cellulose. Moreover, their ingestion level must be greater (artificial selection aims to increase production), which is why they have to consume a large volume of fodder and discriminate very little. In this study, half of the sheep's diet was composed of grasses, this being a very accessible resource, but it has a low nutritional value in autumn. They must, therefore, complement their diet with shrubs and herbaceous vegetation with high levels of intracellular components (Hanley and Hanley, 1982):

It is not known whether the stomach of the domestic goat is larger than the mountain goat's. However, the fact that its diet is almost monospecific suggests a need for greater intake level than for the wild goat. If this were indeed the case, the most accessible resource with an acceptable nutritional value (Rodríguez Berrocal et al., 1973) for a browser in the study area would be evergreen oak twigs.

THE IMPACT OF HERBIVORES ON THE VEGETATION AND IMPLICATIONS OF MANAGEMENT

The four species of herbivores show a clear preference for particular vegetal species which they consume in higher percentages than these species represent in the available vegetation, generally speaking. Given that there is a high density of livestock in the study area, the data obtained better support the idea of a resource partitioning than a diet overlap with increasing possibilities of competition. However, it would be interesting to study further the impact that the domestic animals can provoke on the preferred plant species and the changes that this can impose on the whole system.

BIBLIOGRAFIA

- DUNBAR, R.I.M. (1978). Competition and niche separation in high altitude herbivore community in Ethiopia. E.Afr.Wildl.J. 16:183-199.
- GARCIA-GONZALEZ, R. (1984). L'emploi des épidermis végétaux dans la détermination du régime alimentaire de l'isard dans les Pyrénées Occidentales. Documents d'Ecologie Pyrénéenne, 3-4:307-317.
- GARCIA-GONZALEZ, R. (1987). Estudio del crecimiento postnatal en corderos de raza Rasa Aragonesa ecotipo Ansotano Monografía del Instituto de Estudios Altoaragoneses. n 13. Huesca.
- GARCIA-GONZALEZ, R. Y MONTSERRAT, P. (1986). Determinación de la dieta de ungulados estivantes en pastos supraforestales del Pirineo Occidental. Actas XXVI Reunion Científica de la S.E.E.P. vol I, pp 119-134 junio 1986. Oviedo.
- GORDON, I.J. (1989). Vegetation community selection by ungulates on the isle of Rhum. III. Determinants of vegetation community selection. Journal of applied ecology 26: 65-79.
- HANLEY, T.A. and HANLEY, K.A. (1982). Food resource partitioning by sympatric ungulates on great basin rangeland. Journal of Range Management 35(2): 152-158.
- KASWORM, W.F., IRBY, L.R. and PAC, H.B.I. (1984). Diets of ungulates using winter ranges in northcentral Montana. Journal of Range Management 37 (1):67-71.
- MARTINEZ, T., MARTINEZ, E., and FANDOS, P. (1985). Composition of the food of the Spanish wild goat in Sierras de Cazorla and Segura, Spain. Acta Theriologica 30 (29): 461-494.
- RODRIGUEZ BERROCAL, J. MOLERA APARICIO, M. (1985). Aprovechamiento de los recursos alimenticios naturales. I Contribución al estudio de la dieta del gamo (Dama dama) y del muflón (Ovis ammon musimon) en el área ecológica de la Sierra de Cazorla. Archivos de Zootecnia. 34 (128): 3-23
- RODRIGUEZ BERROCAL, J., ZAMORA, M., GOMEZ, A.G., PEINADO, E., MEDINA, G.M. (1973). La flora arbustiva mediterránea y su valoración. IV. Introducción al estudio de la evolución estacional de la composición nutritiva. Archivos de Zootecnia 22 (88): 321-330.
- SCHOONVELD, G.G., NAGY, J.G., BAILEY, J.A. (1974). Capability of mule deer to utilize fibrous alfalfa diets. J.Wildl. Manage. 38 (4): 823-829.
- SCHWARTZ, C.C. and ELLIS, J.E. (1981). Feeding ecology and niche separation in some native and domestic ungulates on the shortgrass prairie. Journal of Applied Ecology. 18: 343-353.
- VAN DYNE, G.M., BROCKINGTON, N.R., SZOCS, Z., DUEK, T. and RIBIC, C.A. (1980). Large herbivore subsystem. In: BREYMEYER and VAN DYNE (eds). Grass systems analysis and man. pp. 269-537. I.B.P. 19. Cambridge.
- VALLE, F., GOMEZ, F., MOTA, J.F. y DIAZ, C. (1989). Parque Natural de Cazorla, Segura y Las Villas. Guía Botánico-ecológica. 354 pp. Ed. Rueda. Madrid.