Food habits of *Capra pyrenaica*, *Cervus elaphus* and *Dama dama* in the Cazorla Sierra (Spain)

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Summary. — Food habits of sympatric ungulates (wildgoat, red deer and fallow deer) in the Cazorla Sierra (southeast of Spain) have been investigated over two years, in order to assess the possibilities of trophic competition with each other. Wild goat and red deer showed the most similar diets, both having a high intake of ligneous species. Fallow deer showed marked preference for graminoids. All ungulates increase browse consumption in winter. Trophic competition seems to be reduced by means of diet dissimilarities or density differences.

Résumé. — Le régime alimentaire de trois ongulés (le bouquetin ibérique, le cerf et le daim) occupant le même domaine spatial dans le Parc Naturel de Cazorla (sud-est de l'Espagne) a été étudié pendant une période de deux années, pour évaluer les possibilités de concurrence trophique entre eux. Le bouquetin et le cerf ont montré les régimes alimentaires les plus similaires avec une haute consommation d'espèces ligneuses. Le daim montra une forte préférence pour les graminées. Les trois ongulés augmentèrent la consommation de plantes ligneuses en hiver. Les différences entre, d'une part les spécialités trophiques des ongulés, d'autre part leur densité, peuvent réduire les possibilités de compétition alimentaire.

INTRODUCTION

Recent studies on the feeding regime of sympatric ungulates provide evidence, that foraging behaviour of animals during periods of resource-scarcity would be either : i) specialization in one determined plant resource, promoting dietary divergence, ii) or opportunist foraging behaviour, causing great dietary overlap and a potential for interspecific competition (Jenkins and Wright 1986).

The aim of this study is to determine the food habits of three ungulate species (wild goat, red deer and fallow deer) in a specific area and to assess the dietary overlap, especially during periods of resource shortage.

Fig. 1. — Situation of study area (*) and Cazorla, Segura and Las Villas Natural Park.

STUDY AREA

The study was carried out in the Sierra de Cazorla, Segura and Las Villas Natural Park, whose total area is 214.000 ha (Fig. 1). It is situated between latitudes $37^{\circ}45'$ - $38^{\circ}10'$ and longitudes $2^{\circ}40'$ - $3^{\circ}00'$. The geologic sustratum is mainly calcareous. The average rainfall is 1060 mm.

We have selected a representative study area of 0.77 km² situated at 1000 m height. Vegetation belongs to a mesomediterranean betican basophyllous series of holm oak (*Quercus ilex*) forest with pine (Gomez-Mercado 1989). The area is used by three wild ungulates (wild goat, red deer and fallow deer) with 40 indiv./km² of total density.

METHODS

Vegetation sampling.

Herbaceous vegetation and lower shrub stratum were determined by means of a variant of « point-quadrat » method and ligneous vegetation availability

was estimated using « cover » and « line-intercept » methods (Cuartas and Garcia-Gonzalez 1990).

Diet analysis.

Diets were determined by micrographic analysis of faeces (Garcia-Gonzalez 1984). Twenty three wild goat, 27 red deer and 40 fallow deer samples were collected during 1988 and 1989 distributed over six sampling periods which coincided with vegetation measurements.

Animal abundance.

Animal abundance was determined by a combination of fixed observation point and systematic survey methods (Escos and Alados 1988). A census of the study area ungulates was taken over two consecutive days each period.

Data processing.

Dietary seasonal variations were tested by means of a chi-square test. Kulzynski's similarity index (KSI) and a modified Ilvlev's selection index (ISI) were used to estimate diet similarities and food preferences respectively. KSI indicates the percentage of diet which is identical between two animal species and it ranges between 0 % and 100 % (Garcia-Gonzalez and Cuartas 1989). ISI is the ratio between the difference of ingested and available plants and their sum, multiplied by a factor of 10 (Taylor and Koyhmann 1990). This index ranges between - 10 (total rejection) and + 10 (maximum preference).

RESULTS

Diet comparisons.

Figure 2 shows mean ungulate diets. Differences in ligneous, forb and graminoid intake are significant ($\chi^2 = 167.26$ between wild goat and fallow deer ; $\chi^2 = 7.57$ between wild goat and red deer ; $\chi^2 = 156.55$ between fallow deer and red deer ; d.f. = 2).

Fig. 2. — Percentage composition of herbivorous diet ; means of six periods over two years.

Wild goat and red deer have the most similar diets (KSI = 74 %) while fallow deer and wild goat have only 42 % of their diets in common. The similarity index between fallow deer and red deer is also low (KSI = 48 %).

Seasonal variation of diet.

Figures 3, 4, and 5 show fallow deer, wild goat and red deer diets over the three year period. The three species present significant seasonal variations in their diets (table 1). The increase of ligneous intake by fallow deer in February and the great holm oak intake by red deer (75 % in September and February) are remarkable.

FALLOW DEER

Fig. 3. — Seasonal variation of fallow deer diet (mean of two years).

WILD GOAT

Fig. 4. — Seasonal variation of wild goat diet (mean of two years).

RED DEER

Fig. 5. — Seasonal variation of red deer diet (mean of two years).

Table 2 shows seasonal variation of Kulzynski's similarity index values. Wild goat and red deer have high similarity indices throughout the year. Nevertheless, fallow deer have low index values with both wild goat and red deer in May and September, increasing in February.

TABLE 1. — Comparison between seasonal ungulates diets. Chi-square values (* $P < 0.05$).

	Fallow Deer	Wild Goat	Red Deer
MAY - SEPT	12.70*	25.35*	92.96*
MAY - FEBR	197.05*	25.28*	172.64*
SEPT - FEBR	131.98*	0.14	37.53*

TABLE 2. — Kulzynski's similarity indices between wild goat, red deer and fallow deer (in %) in different seasons.

	MAY	SEPT.	FEBR.
Wild goat - Red deer	77	65	78
Wild goat - Fallow deer	20	25	58
Fallow - Red deer	34	32	59

Food preferences.

Figure 6 shows seasonal variation of available vegetation in the study area. Table 3 indicates Ivlev's selection indices between total mean values of ungulates diets and available vegetation.

Wild goat and red deer have moderate preference for ligneous species (ISI = 1.81 and 1.7 respectively), but selection for holm oak is more intense (ISI = 2.36 and 3.64 respectively). Forbs and graminoids are not selected. Nevertheless, fallow deer do not select holm oak or ligneous species. Instead, they select forbs and graminoids.

Fig. 6. — Seasonal frequency distribution of available vegetation distributed in the main food categories (mean of two years).

TABLE 3. — Modified Ivlev's selection indices between average diets and average plant availability.

	Wild goat	Fallow deer	Red deer
Total ligneous	1.81	-1.54	1.70
Quercus ilex	2.36	-1.12	3.64
Others ligneous	1.21	-1.97	-1.79
Forbs	-3.21	3.12	-0.37
Graminoids	-4.78	0.82	-5.67

DISCUSSION

According to Hofmann's classification (Hofmann 1989), the three studied ungulates can be considered as intermediate feeders, although results show an important intake of ligneous plants in all of them. However, the browser trend in wild goat and red deer is larger than that of fallow deer.

No comparative studies on the feeding regime of the three ungulates in sympatry have been found. Nevertheless, cervid feeding trends (red deer being more browser than fallow deer), are similar to those shown by other authors in Mediterranean habitats (Venero 1984, Palacios *et al.* 1984). Results of goat diet show a greater browser tendency than found by Martinez *et al.* (1985) in an extensive area of Cazorla Park. This is probably due to the great browse proportion of available vegetation at our study site. In other zone of Cazorla Park with less browse availability, ligneous intake by wild goat was also lower (Garcia-Gonzalez and Cuartas 1989, Cuartas and Garcia-Gonzalez 1990).

Seasonal quantitative variations in ungulate diets are chiefly explained by seasonal changes in vegetation. Ungulates eat more forbs and graminoids in spring, when their availability is greater. In winter, diet shifts to ligneous components. Nevertheless, vegetation samplings showed an increase of the graminoid cover in February (42 %) ; even greater than in May and September (Fig. 6). This could be explained both by accumulation of dry biomass during previous summer and autumn, and also because of mild temperatures in those particular winters, promoting graminoid sprouting. However, graminoid abundance in February doesn't lead to an increase in graminoid intake, probably because although sprouting increased grass cover, grass biomass did not increase correspondingly. (Sprouting was composed mainly of annuals that died a little later from frost).

The increase of ligneous species' intake in winter also increases animals diet similarity (78 % between wild goat and red deer, 57 % between fallow deer and red deer and 57 % between fallow deer and wild goat). Moreover, the three species preferred holm oak in February and this could increase competition possibilities between them. This trend towards niche overlap increase with food resource reduction, is in accordance with Jenkins and Wright's (1987) results and contrary to those of Dailey *et al.* (1984) ones. Red deer and wild goat coexist spatially, in spite of their high diet overlap, probably due to the different density of both species : 20.8 anim/km² wild goat and 1.9 anim/km² red deer. Fallow deer density (17.3 anim/km²) is similar to that of wild goat, but diet overlap between them is less.

In conclusion the seasonal variation of available vegetation in Cazorla Sierra promotes opportunist foraging behaviour, with greater diet overlap during periods of resource scarcity. However, differences in ungulate trophic specialities (e.g. wild goat and fallow deer) or in animal density (e.g. wild goat and red deer) could diminish potential competition.

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