Structural changes in supraforestal pastures due to current annual growth and grazing in the western Pyrenees, Spain

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Pyrenean supraforestal pastures constitute an important fodder resource throughout the summer. During the annual growing period (snow-free time) vegetation undergoes rapid changes in its physiognomy caused by the incidence of abiotic factors (mainly climatic) and by each plant communities' own features. The herbivores which use these supraforestal pastures find, therefore, a wide and varying food supply. The effect of grazing itself causes subsequent changes in the structure of herbaceous communities. The objective of the study has been to assess structural qualitative changes at plant community level determined by: (i) plant community features, (ii) current annual growth, (iii) grazing.

Materials and Methods

The study was carried out at the headwaters of the Aisa Valley in the Spanish western Pyrenees. The supraforestal pastures under consideration occupy an area of 1700 hectares at an altitude of 1600-2650 m on the hillsides of the Aspes Mountains, mostly south-facing. The lowest part of this common grazing land consists of flat areas and mild slopes with well-made soils. Above 2000 m however, rocky terrain, screes, ledges and extremely steep slopes with mobile substratum predominate, making plant rooting difficult or even impossible and confining herbivores to small areas when looking for food (Garcia-González, Gomez et al. 1990). This substratum is made up of Eocenic limestone and Maestrichiense sandstone giving way to basic soils close to the mother rock but acidified on the surface due to leaching. Low winter temperatures and snowfall reduce the growing period above 2000 m to less than four months. Annual mean temperature in the study area is 7.1°C. Rainfall, excluding snowfall, amounts to 1100 mm per year (average data at 1600 m and 1800 m in study area).

The overall flora of this area shows a predominance of Eurasian and south European orophyte elements and a great number of boreo-alpine and alpine orophyte taxons. The number of species to be found in the study area is just over 480 taxons (nomenclature according to Tutin et al. 1964) whereas above 2000 m the number diminishes to 250. With respect to vegetation, a total of 20 associations included in 15 phytosociological alliances have been determined and mapped (Remón and Gómez 1989), according to the classification and nomenclature of the Zurich-Montpellier School (Braun-Blanquet 1948). *Mesobromion erecti, Nardion strictae, Festucion gautieri* and *Primulion intricatae* are the most widely represented alliances in the pasture land, although areas with no vegetation or with less than 5% covering occupy large areas in the highest territory.

The whole grazing area is utilized by 2000 sheep looked after by shepherds, 300 cows and a few head of goat and mares under free ranging conditions in particular areas of the summer rangeland. There are also 300 chamois (*Rupicapra rupicapra*) which occupy the highest areas in summer (Garcia-González et al. 1990).

During 1989 three plots of 4 hectares each were established at a height of 2000 m and 2250 m. The number and situation of the plots were chosen so that they were representative both of the main plant community types and of the preferred grazing areas. In each plot, emanating from a central point, four 100 m perpendicular transects were fixed, each pointing to one of the cardinal points. In each of the four segments thus formed 500 points separated by 20 cm were sampled. For each of these points the following parameters, among others, were noted: name of plant species first contacted by applying a perpendicular needle on the point; plant state (dry or green); and livestock use (eaten or not). To determine this last parameter, the predominant value in a 2 cm radius circle around the chosen point was considered.

The chosen sampling could be included in the so-called "point methods" (Knapp 1984) with the peculiarity of only considering the highest plant species met with, which supposes an approximation to plant utilization for the large herbivores.

The plots were sampled at four periods (Table 1). The first three were carried out before livestock had entered the summer rangeland and attempts to register the structural changes in the vegetation from the budding period to full flowering (June and July). The fourth sampling was carried out after the livestock's departure and tries mainly to register the changes experienced by the vegetation as a result of grazing.

The number of data gathered is 2000 for each sampling. From this field data, those which showed a clear heterogeneity to the plant community under study were ruled out. The final total of sampling points considered in this paper reaches over 20 000 (8000 in plot A, 6000 in plot B and 7875 in plot C). A large number of contacts in the sampling, spread over a relatively wide area, were necessary to gather the high number of plant species in the grazing area and to obtain the great microtopographical heterogeneity.

Table 1. Dates of sampling period in each plot.

Plots	Sampling Periods			
	I	II	III	IV
A	6-7 June	30 June-2 July	19-21 July	22 Sept.
B	13 June	7 July	26-28 July	2-4 Oct.
C	13-14 June	3-4 July	25 July	7 Sept.

Results and Discussion

The three plots chosen for sampling include three kinds of plant community representative of the most abundant pastureland above 2000 m. Due to the great environmental heterogeneity of this kind of pasture (Tosca et al. 1978) not every plot corresponds to a plant community in a phytosociological sense, although each plot does show the predominance of a plant community and for this reason the name of the predominant alliance has been used to denominate each plot. These are: *Festucion eskiae* (A); *Festucion gautieri* (B) and *Primulion intricatae* (C). A detailed description of the associations can be found in Braun-Blanquet (1948) with regard to the western Pyrenees and in Remón and Gómez (1989) for the Aisa Valley. Fig. 1 shows some variation in parameters throughout the

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sampling of the three studied plots. The altitude of plots are 2050 m (A), 2180 m (B) and 2250 m (C). Plant cover (green plus dry) is very variable: 89%, 48% and 80% during the flowering period (sampling 3) in plots A, B and C respectively. The amount of snow is similar in all three plots and completely disappears after the first sampling. Plot C shows up a higher proportion of dead vegetable matter, particularly in the first sampling, and this would suggest high subterranean small rodent activity. Plot A shows the highest degree of dry vegetable matter which corresponds to the withering of its two predominant species: *Festuca eskia* and *Trifolium alpinum*. Plot B shows the highest amount of stoniness corresponding to the physiognomy of its predominant plant community: *Festucion gautieri* (Remón and Gómez 1989).

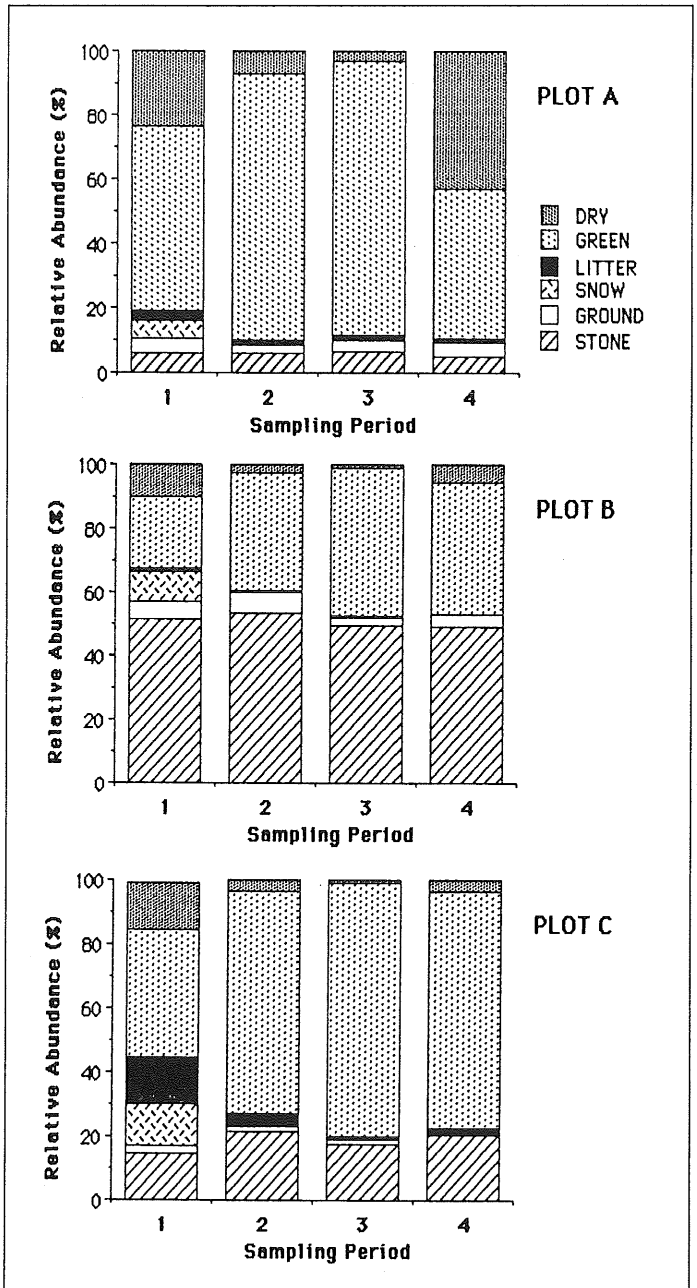

Fig. 1. Temporal variations of relative abundance of main plant and inorganic categories in each of the three sampled plots. Plots A, B, and C correspond to the *Festucion eskiae*, *Festucion gautieri* and *Primulion intricatae* plant communities respectively. Sampling periods as in Table 1.

Evolution in the Species Number, Diversity and Equity

To characterize the structure of the studied plant communities we have used various indices related to the diversity and distribution of the specific frequencies (Peet 1974, Wittaker 1972, Van der Maarel 1988). In every case only the green fraction of each community was considered as attractive for herbivores.

Fig. 2.1 shows the number of species present in each sampling during different seasons. In every case the plot corresponding to *Primulion intricatae* shows the highest values (between 51 and 69) and that of *Festucion eskiae* the lowest (between 23 and 31). In both communities the variation is very similar with its maximum in the third sampling, corresponding to the highest degree of flowering, and a decrease in the fourth sampling due to several species withering. *Festucion gautieri* shows an intermediate number of species with a peak in the second and fourth sampling. The decrease in species number in the third sampling can be explained by the maximum development which is reached by the most frequent plants, hiding the sporadic ones.

As for the diversity measured by the Shannon-Weaver index (H', Fig. 2.2), high values appear in *Primulion intricatae* (3.77-4.19) and in *Festucion gautieri* (3.53-4.04) and relatively low ones in *Festucion eskiae* (2.40-3.09). In this plot a steep rise is produced in the last sampling which is related to the withering of *Festuca eskia* and *Trifolium alpinum* and which allows a higher representation of the other species. The high diversity value in *Primulion intricatae* is mainly a consequence of the great number of species, whereas in *Festucion gautieri* it means a greater similarity between the frequencies of a lower number of species, as can be seen from the higher equity values in plot B.

The Simpson index (Fig. 2.3) shows the clear predominance of *Trifolium alpinum* in *Festucion eskiae* (plot A) which decreases to less than half in the last sampling due to withering of this species and *Festuca eskia*. Much lower values are found in the other two plots. In all cases there is a decrease of predominance throughout the vegetative period except for a small final ascent in *Primulion intricatae*.

Equity, measured by the Pielou index (Fig. 2.4) shows the highest values in *Festucion gautieri*, medium and very constant in *Primulion intricatae* and very low in *Festucion eskiae* except in the last sampling, after the decrease in *Trifolium alpinum*.

The evolution of the green: dry matter ratio (Fig. 3.1), shows the normal phenologic development. In the three plots similar changes with similar initial values (2.21, 2.47, 2.55) can be seen along with a moderate increase in the second sampling and a strong one in the third (50, 27.25 and 74.95). The sharp decline in September and October marks the beginning of the end of the vegetative period which does not last longer than this even though temperatures remain mild and no snow appears until the end of the year. There seems to be a direct relationship between altitude and the green/dry ratio. This could be related to a shorter vegetative period in the higher plots or possibly to greater grass production in the lower plots. This fact is important to herbivore grazing and its stratification (Garcia-González et al. 1990). However, more experimental evidence is needed before this hypothesis can be verified.

Evolution of the Monocotiledon/Dicotiledon Ratio

The family distribution of plant species in the whole summer varies (Gómez, unpublished data), showing the highest values of grasses and Compositae (about 10% each) whereas sedges and legumes make up less than 5% (a little over 20 species). Altogether the number of monocotiledoneous species comes to about 100 (less than 20% of the total) of which over half are grasses (52) and almost a quarter are Cyperaceae (22).

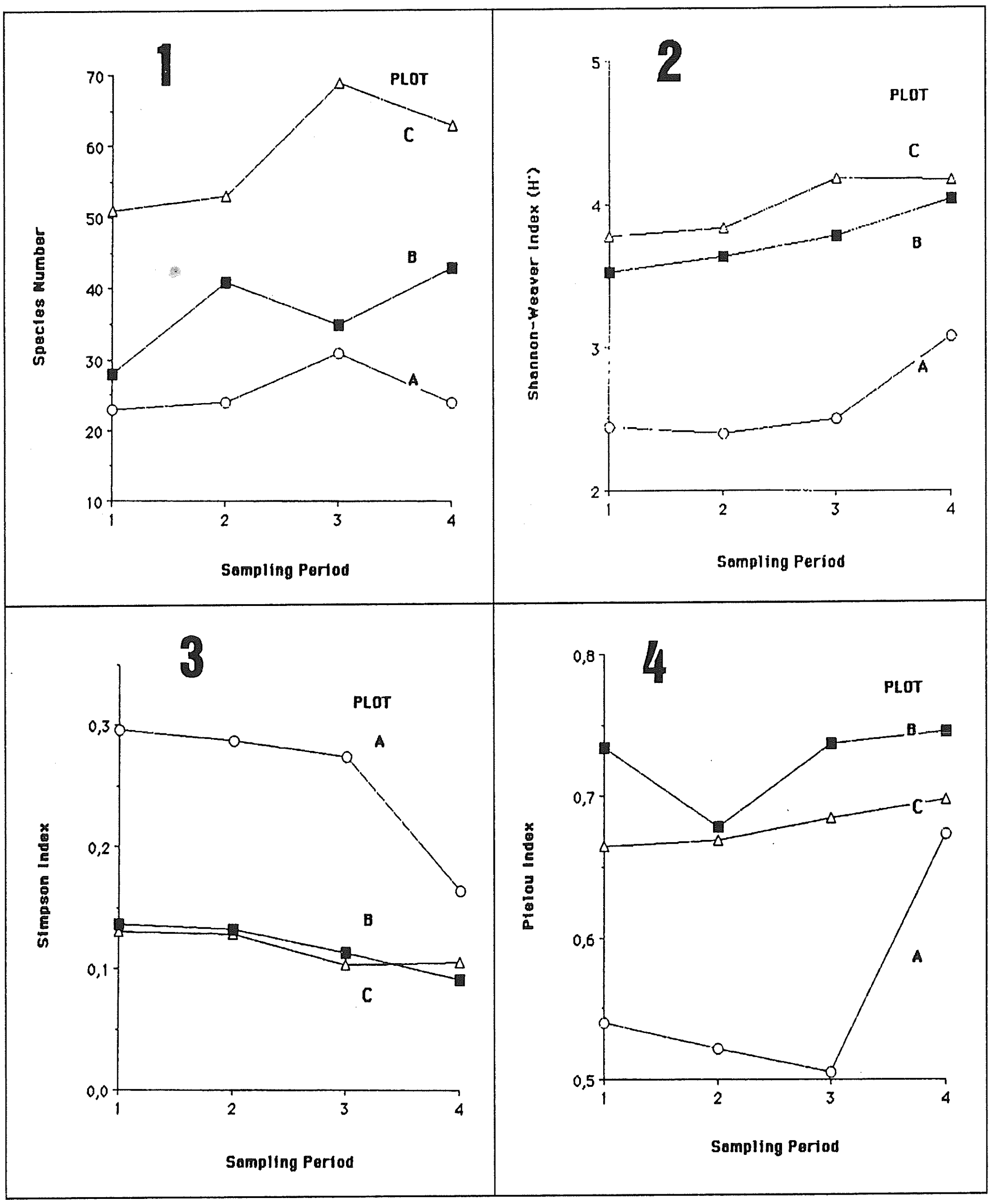

Fig. 2 Time changes of species number (1), plant diversity (2), dominance (3), and equity (4) relative to the green plant fraction in each sampled plot. Plots A, B, and C as in Fig. 1. Sampling periods as in Table 1.

Fig. 3.2 shows the evolution of the monocotiledon/dicotiledon ratio in the three plots throughout the summer. The predominance of monocotiledoneous species is total if we ignore the first two samplings of *Festucion eskiae* (0.87 and 0.95) which nonetheless show a final higher value (3.15). This irregular trend is yet again, due to the specific development of *Trifolium alpinum* which makes up 50% of the total in the first sampling and falls to 18% in the last, thus favouring grasses. *Primulion intricatae* and *Festucion gautieri* (plots C and B) show similar trends with higher values in the first samplings (1.55 and 2.57 respectively) and a decrease or maintenance of these values at later dates. In *Festucion gautieri* the high initial values of some grasses (*Festuca gautieri, Festuca rubra, Koeleria vallesiana* and *Poa alpina*) are neutralized afterwards by the new shooting of a number of dicotiledons such as *Thymus praecox, Galium pyrenaicum* and *Lotus alpinus*, although *Helictotrichon sedenense* and especially *Festuca indigesta* reach their higher representation in the later samplings.

It should be noted that the predominance of monocotiledons is basically due to grasses and among these very few species (*Festuca nigrescens* subsp. *microphylla, Festuca eskia, Festuca gautieri, Festuca rubra, Poa alpina, Koeleria vallesiana, Alopecurus gerardi* and *Helictotrichon sedenense*) make up between 50% and almost 75% of the total on this pastureland. The remaining monocotiledons do not reach 1.5% in plots B and C; only in *Festucion eskiae* can we find a value of 9.7% for this test in the first sampling (due to the quantity of *Carex caryophyllea* at 5.9%) although it later decreases and settles at values between 2.9% and 4.2%.

With respect to dicotiledons, a predominance of non-leguminosae can be appraised reaching values of between 20% and 33% in plots B and C even though shared out among a high number of species. *Festucion eskiae* shows a high degree of leguminosae due to only one species (*Trifolium alpinum*) which, until it withers, makes up almost half the plot in terms of abundance.

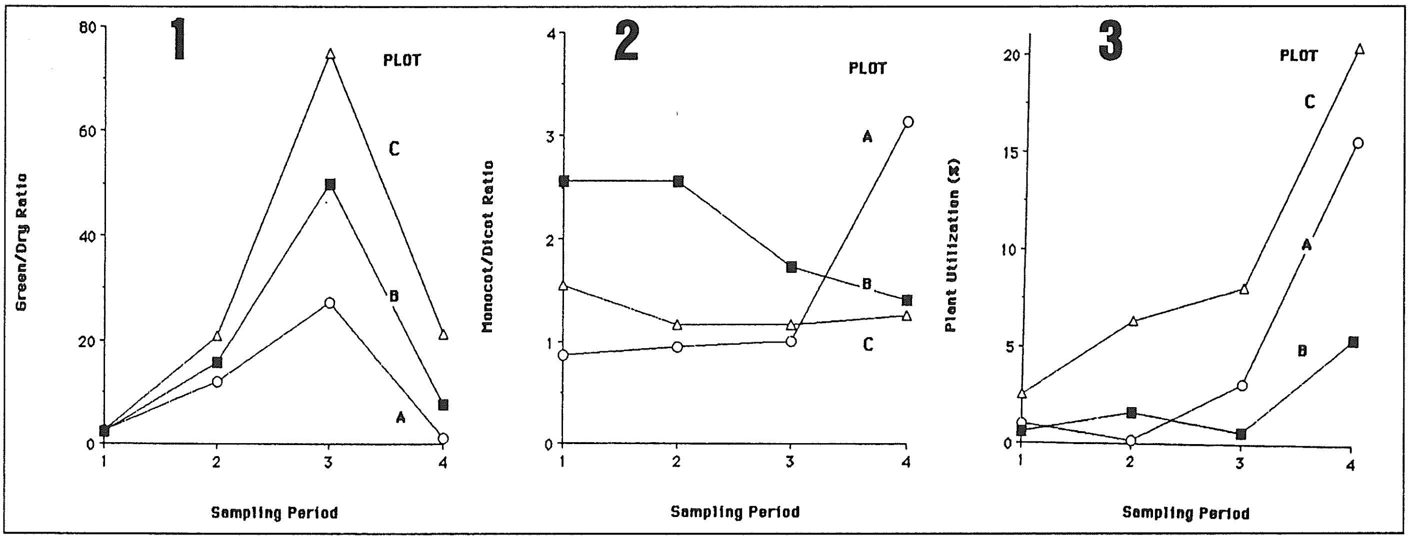

Fig. 3 Changes of green/dry ratio (1), monocotiledon/dicotiledon ratio (2), and herbivore utilization (3) during the summer period in each sampled plot. Plots A, B, and C as in Fig. 1. Sampling periods as in Table 1.

Plant Utilization by Herbivores

Fig. 3.3 shows the percentage of plants showing evidence of having been eaten by herbivores over the total green fraction per plot and sampling period. As can be seen the incidence on vegetation is moderate in the first three samplings, whereas in the fourth the percentage of eaten species goes up, mainly due to the domestic herbivores.

Plot B (*Festucion gautieri*) is that which shows the least relative use, reaching as little as 5.5% of eaten plants in the last sampling. Of these, half correspond to *Helictotrichon sedenense*. The little use of this plot could be a result of its scarce plant cover (Fig. 1), which decreases the supply, and the predominance of low digestible grasses: *Festuca gautieri, Festuca indigesta* and *Koeleria vallesiana* which represent 50% of the green phytomass.

Plot A (*Festucion eskiae*) was grazed mainly by cows and mares. The predominant species (*Festuca eskia*) is usually rejected by ruminants but not by mares, whose digestive (cecal digestion) allows them to take better advantage of roughage (Janis 1976). *Festuca eskia* represents half the green phytomass grazed in this plot at the end of the summer (7.7%). The second most important species in plot A is *Trifolium alpinum*, a legume high in nutrients (Garcia-González and Alvera 1986) but which withers early, limiting its use at the end of the summer. Nevertheless, in the third sampling it is the most grazed species: 2.6% of a total of 3.1% eaten green contacts. Its consumption is mainly due to cattle grazing.

Plot C shows the highest degree of use at the end of the summer, in spite of the livestock's short stay. Its relatively high use is probably due to the high nutritive quality of the predominant species (*Festuca nigrescens* subsp. *microphylla*, *Poa alpina* and *Trifolium alpinum*) and the long stay of the wild herbivores in that area: chamois and in smaller numbers, marmots. It is likely that their wide diversity has an attractive effect on the herbivores. The most consumed species is always *Festuca nigrescens*, which agrees with the information gathered about the chamois' diet by fecal analysis methods (Garcia-González and Montserrat 1986) not forgetting that this plant is also the most abundant.

Conclusion

In this study the structural changes that take place throughout the summer on the most exploited areas above 2000 m have been analysed. This pastureland represents, in the main, three plant communities of great quantitative importance on the subalpine floor and the subalpine Aragonese Pyrenees.

The results show that features of different pastureland areas are extremely variable and basically depend on the predominant vegetation community. In fact, there are few species that the three studied plots have in common, despite being separated by only a few hundred metres. On the whole it can be stated that the structural changes produced during the vegetative period are not excessively important if we ignore the variation in the species number in two of the areas and obviously, the green/dry ratio. The different indices used in evaluating the structural features of the vegetation show the most important variations in the last sampling, at the end of the summer, caused by withering and the passage of domestic herbivores.

Vegetation structure analysis, even without considering productive aspects, shows that certain plant communities (e.g. *Primulion intricatae*) have structural features very suitable to small ruminant grazing (high diversity, high green/dry ratio, balanced monocotiledon/dicotiledon ratio). Other communities such as *Festucion eskiae* and those which predominate below 2000 m (*Mesobromion erecti* and *Nardion strictae*) seem more suitable for large herbivores.

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