Plant production and nutritive quality of savannah-like grasslands (*dehesas*) in semi-arid zones of the province of Salamanca

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Abstract

A study was made of two savannah-like (*dehesa*) pastures on which cattle (*Morucha* cows $\times$ *Charolais* bulls) are raised for beef. The soil of *dehesa* system A was developed over slate, while that of B was developed over granite. The type of vegetation, dry matter yield (DM), raw protein (RP) content, digestible organic matter (DOM) content and the metabolizable energy (ME) of each system was determined to provide the nutritive value of the two types of pasture. Dietary supplements were assessed in the same way. The DM yields for 1989, 1990 and 1991 were 751, 1900 and 1438 for system A, and 577, 1937 and 1361 kg ha^{-1} for system B. The RP values for April and December were $17.6 \pm 1.4\%$, falling to a minimum of $6.7 \pm 0.4\%$ in July-October. Intermediate values were seen for the rest of the year. The ME showed mean values of 9.4 ± 0.3 and 7.9 ± 0.2 MJ kg DM^{-1} for systems A and B respectively, while mean metabolicity was 0.50 ± 0.2 and 0.44 ± 0.1 (P < 0.05) and the DOM was $67.5 \pm 4.2\%$ and $44.3 \pm 3.9\%$ respectively. These values were affected by the year and harvest date (P < 0.05) and were always greater (P < 0.05) on soils developed over slates. The greatest pasture ME was achieved in spring and represented some 77-95% of total pasture production, depending on the year. Supplements represented approximately 20% of the total available ME.

Key words: pastures, seasonality, mineral content, feed offer.

Resumen

Producción vegetal y calidad nutritiva de sistemas adehesados en zonas semiáridas de la provincia de Salamanca

Se caracterizaron dos sistemas adehesados de pasto sobre suelos formados por la descomposición de pizarras (sistema A) y granitos (sistema B), dedicados a la producción de carne en extensivo, con vacas de raza morucha cruzadas con toro charolés. Se estimó el valor nutritivo de los pastos y de la alimentación suplementaria a partir del tipo de vegetación y producción de materia seca, proteína bruta, materia orgánica digestible y energía metabolizable. La producción en los años 1989, 1990 y 1991 fue, respectivamente, de 751, 1900, y 1438 kg DM ha^{-1} en pizarras, y 577, 1937 y 1361 kg DM ha^{-1} en granitos. En ambos sistemas, la media de proteína bruta alcanzó valores máximos de $17,6 \pm 1,4\%$ en los meses de abril y diciembre, y mínimos de $6,7 \pm 0,4\%$ en el periodo de julio a octubre; el resto del año valores intermedios. La materia orgánica digestible presentó contenidos medios de $67,5 \pm 4,2\%$ y de $44,3 \pm 3,9\%$; la energía metabolizable, valores medios de $9,4 \pm 0,3$ y $7,9 \pm 0,2$ MJ kg DM^{-1}, y metabolicidad media de $0,50 \pm 0,2$ y $0,44 \pm 0,1$. Estos contenidos fueron mayores (P < 0,05) en el suelo de pizarras, y en ambos suelos estuvieron influenciados por el año y la fecha de corte (P < 0,05). La oferta de energía metabolizable de primavera fue 77-95% de la producción total del sistema, y la suplementación energética el 20% de ésta, valor que confirma el carácter extensivo de estas explotaciones.

Palabras clave: pastos, periodo de producción, contenidos minerales, oferta alimenticia.

Introduction

On the beef production ranches of the savannah-like grasslands (*dehesas*) of central-western Spain, the main food resource for livestock is pasture. However, there are periods when pasture species do not grow, and cattle diets need to be supplemented. This period normally lasts six months, but can go on for longer if temperatures and rainfall are below normal. Stock management and the stocking rate also influence the length of this period. Jarrige (1980) indicates that extensive systems must carefully manage ecological, historical, economic and sociocultural factors.

To maintain their live weight, adult ruminants require forage with a digestibility of 45%, if greater, enough energy is available for fattening or for work (Ward and De Gracia, 1986). The metabolizable energy (ME) is the fraction of the food that animals actually make use of (McDonald *et al.*, 1986).

Bellido *et al.* (1986) established the energetic balance for *dehesa*s of southwestern Spain, taking into account the energy provided by pasture and supplementation, the nutritional needs of the animals, and the production of meat.

The aim of the present work was to characterise two *dehesa* systems representative of the Province of Salamanca (central-western Spain). This involved estimating the primary production of pasture and acorns and the botanical composition of the available vegetation over three years, as well as determining the coefficients of digestibility of the organic material, its raw protein content (RP), the ME of the pasture and supplements, and, finally, the balance between available energy and animal needs.

Material and Methods

Edapho-climatic characteristics of the two dehesa systems

The experiment took place between the spring of 1989 and the autumn of 1991. Two representative *dehesa* systems were chosen, both developed over Tertiary beds, system A, an area with slate soils in the municipality of San Pedro de Rozados, and system B, an area with granite soils in the municipality of Villasdardo. These soil types occupy some 80% of the stock raising land in the Province of Salamanca. They are both shallow (30-40 cm), sometimes with rocky outcrops, and of low water-retaining capacity (except in low-lying areas with loam or sandy loam soils) (García Rodríguez, 1966).

Aerial photography was used to estimate the total surface area available for grazing in the two *dehesas*, i.e., the total surface area minus the unproductive area. For system A, the grazing area was 489 ha, distributed over nine enclosures with high, middle and low ground and with a slope of 14-74%. System B had a grazing area of 358 ha, distributed over six enclosures with high and low ground and a gradient of < 7%. The mean altitude of the greater study area was 800 m.

Surface horizon soil samples (0-25 cm) were taken for chemical and mechanical analyses. For each slope position (high, middle and low), 100 original samples were taken. These were then divided into 10 groups of 10 samples each, the contents of which were mixed for analysis.

The soils on which the *dehesas* are developed were acidic with high organic matter (OM) and low calcium contents. These contents increased from the high toward the low-lying ground, OM from 2.7 to 4.3% and Ca from 355.0 to 1060 mg kg^{-1} on the slate soil of system A, and from 2.8 to 3.5% and 40.0 to 356.0 mg kg^{-1} respectively on the granite soil of system B. P and K, however, were found in greater amounts on the higher ground. Mean P values were 5.0 mg kg^{-1} on high ground and 3.6 mg kg^{-1} on low ground for the slate soil of system A, and 7.6 mg kg^{-1} on the high ground and 4.1 mg kg^{-1} on the low ground for the granite soils of system B. Similarly, mean K values were 192.0 mg kg^{-1} on the high ground and 138.9 mg kg^{-1} on the low ground of system A, and 142.6 mg kg^{-1} on the high ground and 87.7 mg kg^{-1} on the low ground of system B. The P content of all these soils was therefore deficient, while K was sufficient in the high areas but deficient in the low areas. This agrees with the results of Martín Polo and Prat (1983).

Rainfall data were provided by the *Centro Meteorológico Territorial de Castilla y León* and collected at the meteorological stations closest to the two *dehesa* systems. Temperature data, collected at the Muñobela meteorological station (in the municipality of Barbadillo) were common to both systems.

During the study period, records were made of seasonal and annual rainfall and minimum temperatures. The mean rainfall for winter, spring, summer and autumn was 117.3, 104.8, 52.1 and 194.2 mm in system A, and 115.0, 102.1, 36.2 and 205.2 mm in system B. The mean rainfall of the last 30 years for system A was 160.3, 136.9, 61.5 and 167.7 mm for the same seasons, while that of B for the last 26 years was 151.6, 122.9, 51.0 and 163.5 mm respectively. The mean seasonal minimum temperatures (the same for both systems) were –0.2, 5.7, 12.0 and 2.9°C respectively. The mean minimum temperatures of the last 17 years for these same four seasons were –0.67, 5.4, 10.41 and 2.44°C. The study period was therefore warmer and drier than normal, except during the autumn.

Characterisation of the flora, primary production and main nutrients of the available pasture

The most important primary production of these systems was pasture and acorns.

An initial survey was undertaken to determine at macroscopic level the types of pasture communities present. Plant inventories were produced during the period of greatest development (end of May – beginning of June) by random sampling of the different communities. This was performed using a 0.5×0.5 m quadrat thrown at least 5 times to obtain samples approximately coinciding with ground level.

Exclusion cages (1×1.5 m) with four compartments were used to estimate the primary production of the pasture. Four readings were taken in spring (at the beginning of May, June and July) and two in autumn (the middle of October and December). Samples for the different tests were taken by harvesting quadrats (0.5×0.5 m, 3 cm from the ground) and measuring the growth of two successive harvests. The number of cages used depended on the size of the area examined: 58, 23 and 29 cages were placed on the high, middle and low ground areas respectively. In 1989, only two control values were made in spring since the experiment started in May.

Pasture samples were dried at 60ºC for 48 h before grinding and passing through a 1 mm sieve to provide material for further analysis. Dry matter was measured after keeping the material at 105ºC for 24 h. The OM content was determined by calcination at 460ºC overnight, raw protein (RP) was calculated from the Kjeldahl N content $\times$ 6.25, neutral detergent fibre (NDF) was estimated according to Van Soest *et al.* (1978), and the digestibility of organic matter (DOM) by the neutral detergent-cellulase assay (Bassery and Campling, 1988). ME was estimated from the DOM using the equation $ME = 5.406 + 0.058$ DOM (Martín Polo and García Bellido, 1995).

Total ME (TME) obtained at each cutting time (harvest) was calculated by multiplying the available grazing area (in ha) by production per ha (in kg DM ha^{-1}), and from the ME content of the dry matter (DM) (in MJ kg DM^{-1} 1000^{-1}).

Acorn production

To calculate the primary production of acorns, the number of trees was estimated from aerial photographs. For an area of 489 ha and a density of 20 holm oaks per ha, Vázquez *et al.* (2001) recommend sampling 33 trees as well as checking 10-15 additional specimens to see whether they have acorns, and then determining the ratio of acorn producers/non-producers. In this work, acorn production was measured every year by sampling

trees in each enclosure (at least one tree from the high, middle and low ground areas in system A, and one from the high and low areas in B). The numbers of producing and non-producing trees per enclosure were also estimated. Eighty one trees were sampled from system A and 54 from B over the study period. The influence of the trees on the pasture was not taken into account, nor was the nutrient supply from the litterfall.

Supplementation

Nutritional supplementation of the cattle was undertaken with alfalfa, meadow and vetch-oat hay, straw, maize, barley, oats, soy flour and cereal feed, but in very different quantities according to the year and system. The energy content of the hays was estimated using the methods described above. For the other components, the tables of McDonald *et al.* (1986) were used.

Daily samples of whatever was provided were taken and the weight of these products recorded every 15 days. The monthly and annual ME intake was then calculated. A 5% loss of feed, distributed in the field, was assumed (Gaillard, 1989).

Stocking rate and management

The two systems are used to raise native *Morucha* cattle for beef (*Morucha cows $\times$ Charolais bulls*). The stocking rate was 0.55 and 0.43 cows ha^{-1} year^{-1} in systems A and B respectively; the mean live weights of adult cows were 360 kg in A and 440 kg in B. Calves were weaned at six months of age.

The different enclosures were grazed in rotation, the stock raiser deciding when the pasture was used up. The higher enclosures were grazed first (since these dry out earlier), followed by the middle and then low areas. In years in which a lot of grass is produced, some lower areas are reserved for feed harvesting, but this did not occur during the experimental period.

Statistical analysis

ANOVA was used to study the influence of year, harvest time, and high, middle and low slope position on the quantity and quality of primary production.

Differences between means were analysed using the Student t test. RP, NDF and digestibility were studied separately and together by year, harvest time and slo-

pe, and the relationships between these variables assessed by simple and multiple linear regression. All calculations were made using Statgraphics Plus 2.1 software for Windows 95.

Results and Discussion

Botanical composition of the pasture

The plant inventories were similar to those recorded by Rico *et al.* (1979) over a wider area of the region. The herbaceous vegetation, in agreement with the topography, was distributed following eutrophia-oligotrophia gradients from the damper to the drier areas. Humid pasture of *Agrostis castellana* was found in the low-lying areas of stream beds, while pasture of *Agrostis castellana* of different trophic nature was detected at mid slope, and pasture containing ephemeral species was seen in the highest areas (where soils are very thin and there are outcroppings of rock). Table 1 shows the species most frequently seen (and with the highest biomass) according to their position on the slope in both systems A and B (there is no middle zone in system B).

Primary production

Table 2 shows the mean pasture production for the three years according to harvest time and slope position. The standard deviation shows that this production was very different from one year to another, as is to be expected in an area with such changeable climate and where rainfall and temperature are limiting factors (Garmendia, 1965).

Table 1. Pant species most commonly found in the sampled area

Slope position	Most common species	% of the biomass sampled
Low	*Agrostis castellana Boiss* and Reuter *Arrhenatherum elatius* L. *Vulpia bromoides* L. *Plantago lanceolata* L.	30%
Mid	*Bromus hordeaceus* L. *Erodium cicutarium* L'Herit *Vulpia bromoides* L. *Taeniatherum caput-medusae* L. *Agrostis castellana* Bois and Reuter *Trifolium striatum* L. *Plantago lanceolata* L.	35.0%
High	*Arrenatherum elatius* L. *Vulpia bromoides* L. *Erodium cicutarium* L'Herit *Plantago lanceolata* L. *Taeniatherum caput-medusae* L. *Trifolium striatum* L. *Convolvulus arvensis* L.	28.7%

Maximum production was reached in spring, with mean values of 2,549 and 2,363 kg DM ha^{-1} (Table 2) in May in systems A and B respectively. The autumn (December) production was 732 and 644 kg DM ha^{-1} respectively. With respect to slope position, the lowest areas were the most productive (in low areas on more fertile soils). The annual mean production of the harvest of 1989, 1990 and 1991 was 751[a], 1,900[c] and 1,438[b] kg DM ha^{-1} for system A, and 577[a], 1,937[c] and 1,361[b] kg DM ha^{-1} for B

Table 2. Mean pasture production by harvest and slope position over the three years of the study

Harvest	System A			System B		
	n	Mean production (mg DM ha^{-1})	SD	n	Mean production (kg DM ha^{-1})	SD
April*	181	1,212	490	100	1,484	788
May*	202	2,549	776	102	2,363	735
June	309	2,232	1,400	149	2,182	1,050
July	302	1,912	1,270	140	1,767	847
October	277	732	110	146	644	481
December	295	84	10	146	197	62
High slope position	832	1,327[a]	654	549	1,206[a]	563
Mid slope position	345	1,305[a]	605			
Low slope position	389	1,734[b]	1,643	234	1,806[b]	945

* Only 1990 and 1991 considered. n: number of observations. SD: standard deviation. [a,b]: values with different letters for different parts of the slopes of each system are significant (P < 0.05). System B soils have no mid slope position.

(the letters a, b and c represent significant differences at P < 0.05). These results were obtained taking into account the surface area and production of each height zone at each harvest. The differences between harvests and between years were significant (P<0.01).

Calvo *et al.* (1997) obtained a mean production value for the Extremadura (southwestern Spain) *dehesa* of 1,200 kg DM ha^{-1}. For the same area as the present work, Pérez *et al.* (1995), recorded a production of 1,260–3,040 kg ha^{-1} depending on slope position and the botanical composition of the area.

Annual acorn production was estimated at 14,800, 35,250 and 30,811 kg for system A, and 32,207, 4,436 and 18,499 kg for system B in 1989, 1990 and 1991 respectively. These large fluctuations in acorn production depend mainly on the weather conditions of each year. Spring frosts have a negative effect, as do high temperatures at the end of summer. With respect to location and orientation, those areas facing south are the most productive. Clearing and pruning favour production, as does landworking for cultivation. (No data are actually available for the region; all the above are personal observations.)

Chemical composition of the biomass produced

Table 3 shows the mean chemical values of DM, MO, RP, NDF and DOM per harvest for the three years of the experiment. An increase was seen in DM from 22-86% between April and October due to the phenological development of the plants in both systems, as well as to slope position. RP fell from April (16.7%) to October (6.6%) but recovered in December (18.8%). Significant differences were seen between the harvests of each year (P < 0.05), but not between years for the same harvest, except for that of December 1990.

NDF increased as the plants matured, with significant differences between months (P < 0.05), but not between systems nor with respect to slope position. For example, the mean NDF for the month of April was 43.7 and 50.9% in systems A and B respectively, while in October these figures were 73.9 and 74.8%. In June and July of 1989, the NDF was greater (P < 0.05) than in other years.

Digestibility fell with the maturation of the plants (P < 0.05) from 73.0 and 62.5% in April to 38.8 and 40.6% in October in systems A and B respectively. In December it recovered again (60.5 and 60.2%). Neither

year nor slope position affected this, although the harvest date did have an influence (P < 0.05). System A produced a better quality product than system B (P<0.05).

The DOM coincided with the mean annual value (55.5%) estimated by Bellido *et al.* (1986) for *dehesa* pasture.

In May and June in the present study area, Rico *et al.* (1986) obtained RP of 11.0 and 6.9%, NDF of 51.2 and 61.7%, and DMD of 66.8 and 62.7% respectively. Also for the same area, Pérez *et al.* (1998) obtained an RP, DOM and NDF in agreement with those of the present work, according to slope position and time of year.

Table 4 shows the DM, ME, metabolicity (q) and TME of the available pasture at the different harvests of different years. ME varied between 7.6 and 10.0 MJ kg DM^{-1}, less than that indicated (10.8 MJ kg DM^{-1}) for semi-arid pastureland by Corbett (1981), or for damp areas (11.2 MJ kg DM^{-1}) by Givens *et al.* (1989). This difference is probably due to differences in the vegetation. Early *et al.* (2001) considered diets with 9.9, 10.3 and 11.4 MJ kg DM^{-1} to have low, medium and high ME respectively. The metabolicity measured (q) was between 0.43 and 0.52, in line with the value of 0.45 obtained by Susmel *et al.* (1987) for Mediterranean pastureland, and the 0.5 indicated by Guevara *et al.* (1991) for gramina pasture.

For systems A and B, the ME of early spring and late autumn pasture was medium (9.0-10.0 MJ kg DM^{-1}), and therefore apt for nursing cows. From June to October however, when values are < 8.5 MJ kg DM^{-1}, this pasture is only good for non-lactating cows (McDonald *et al.*, 1986). Though no hard data are available for the study area, experience shows that with the current management system the greatest number of births (80%) occurs in spring between March and June. According to the results, it could be necessary to supplement mother cows from July through to the end of October.

The energy supplied (GJ year^{-1}) by the primary production of acorns is estimated by assigning according to Bellido *et al.* (1986) a dry matter content of 60% and an ME of 9.8 MJ kg DM^{-1}. The values obtained for systems A were 87, 207 and 181 for 1989, 1990 and 1991 respectively, while system B showed values of 189, 26 and 108.

Total production and supplementation of systems A and B

The products used to supplement the diet of the cattle were considered as inputs to the ecosystem.

Table 3. Mean pasture values for dry matter (DM), organic matter (OM), raw protein (RP), neutral detergent fibre (NDF) and digestible organic material (DOM) for the three years, by harvest date and slope position

| Harvest date/ slope position	Variable (%)	System A				System B			
		n	Mean	SD	Range	n	Mean	SD	Range
April*	DM	46	21.9	0.24	19.1-23.7	20	23.2	0.44	20.2-24.5
	OM		88.8	2.20	80.2-92.2		90.8	1.14	88.1-92.4
	RP		17.0	1.36	14.0-20.6		16.4	1.18	14.2-18.8
	NDF		43.7	6.84	30.3-58.3		50.9	4.85	40.7-63.2
	DOM		73.0	5.62	57.1-18.4		62.5	5.74	45.9-69.3
May*	DM	47	25.5	0.71	20.0-28.2	20	26.8	0.50	22.1-30.6
	OM		91.1	1.00	89.0-93.5		92.1	2.13	88.1-97.8
	RP		11.6	1.85	6.7-16.7		12.1	1.73	9.9-15.4
	NDF		49.7	7.48	32.2-63.5		55.7	5.23	47.1-64.8
	DOM		63.8	6.17	51.3-80.4		58.0	5.20	49.1-65.0
June	DM	69	31.2	1.00	25.7-35.4	30	32.5	1.19	27.5-36.0
	OM		91.6	1.23	87.7-94.5		92.8	1.48	88.9-97.8
	RP		9.9	1.84	7.5-14.7		9.2	1.08	7.3-12.1
	NDF		60.6	6.97	43.7-71.2		66.6	4.26	58.2-74.1
	DOM		52.3	5.87	44.1-67.0		44.3	4.99	35.2-56.1
July	DM	70	72.6	8.70	63.4-75.0	30	70.7	1.14	66.5-76.4
	OM		91.9	1.66	86.6-95.8		96.3	1.48	89.6-97.8
	RP		7.1	1.14	5.0-10.3		6.4	1.05	4.0-8.5
	NDF		65.0	6.56	46.5-74.7		70.4	4.78	60.0-79.6
	DOM		47.6	5.90	35.3-64.1		42.1	5.54	34.8-55.3
October	DM	45	86.0	1.14	80.0-89.1	20	87.5	1.21	78.3-89.7
	OM		93.0	1.88	84.4-95.8		93.7	2.07	89.9-97.8
	RP		6.3	1.03	4.5-9.0		7.0	1.86	5.3-13.3
	NDF		73.9	6.40	58.1-83.5		74.8	4.77	62.4-81.8
	DOM		38.8	3.00	27.7-54.8		40.6	3.80	32.3-51.4
December	DM	54	22.0	1.24	18.0-25.3	30	21.2	1.77	17.8-24.0
	OM		85.9	3.43	77.8-91.1		89.3	3.50	81.4-97.7
	RP		17.5	2.40	13.1-23.0		20.2	1.70	18.4-26.1
	NDF		52.4	6.01	38.6-69.6		53.8	9.75	26.8-77.3
	DOM		60.5	7.16	43.6-70.8		60.2	8.71	40.0-84.2
High slope position	DM	175	45.2	1.06	40.3-51.1	75	46.7	1.59	42.5-50.0
	OM		90.7	3.02	79.6-95.8		92.2	2.89	81.4-97.8
	RP		11.2	4.64	5.3-23.0		12.0	5.39	4.6-23-1
	NDF		58.1	11.88	30.3-83.0		61.4	10.0	39.4-80.3
	DOM		55.3	12.22	27.7-83.2		52.1	10.1	34.2-73.6
Mid slope position	DM	69	40.3	0.98					
	OM		90.0	3.58	77.8-94.5				
	RP		11.1	4.17	4.5-19.3				
	NDF		55.7	12.21	30.8-83.3				
	DOM		56.9	12.31	28.9-84.4				
Low slope position	DM	87	33.1	1.14	29.6-36.3	75	35.0	1.41	31.4-39.0
	OM		90.4	2.76	80.1-95.8		91.8	2.51	82.4-96.8
	RP		11.8	4.81	4.7-21.7		11.7	5.51	4.0-26.1
	NDF		59.9	10.21	40.2-79.8		63.2	11.7	26.8-81.8
	DOM		54.1	11.85	30.6-74.5		49.6	11.4	32.3-84.2

* Man for 1990 and 1991. n: number of observations. SD: standard deviation.

Table 4. Dry matter of available pasture (DM), metabolizable energy (ME), metabolicity (q) and total metabolizable energy (TME) by harvest and year

Harvest	System A				System B			
	DM (kg ha⁻¹)	ME (MJ kg DM⁻¹)	q	TME (GJ ha⁻¹)	DM (kg ha⁻¹)	ME (MJ kg DM⁻¹)	q	TME (GJ ha⁻¹)
20-6-1989	1,320	8.2	0.45	5.29	812	7.9	0.44	2.30
14-7-1989	936	8.1	0.45	3.71	591	7.7	0.43	1.63
4-10-1989	650	7.6	0.43	2.41	400	7.6	0.43	1.09
18-12-1989	290	9.4	0.48	1.30	191	8.9	0.47	0.61
16-4-1990	1,298	9.9	0.52	6.24	1,598	9.2	0.49	5.26
14-5-1990	2,238	9.0	0.49	9.85	2,375	8.8	0.48	7.48
5-6-1990	2,887	8.6	0.47	12.14	2,641	8.1	0.45	7.66
3-7-1990	2,211	8.3	0.46	8.97	2,364	8.0	0.45	6.77
1-10-1990	1,463	7.9	0.44	5.65	1,029	7.6	0.43	2.80
12-12-1990	112	10.0	0.52	0.55	142	9.2	0.49	0.47
15-4-1991	951	9.6	0.51	4.46	1,113	9.1	0.48	3.63
20-5-1991	2,539	9.1	0.49	11.30	2,449	9.0	0.49	7.89
10-6-1991	1,911	8.5	0.47	7.94	2,170	8.3	0.46	6.45
5-7-1991	1,688	8.1	0.45	6.69	1,086	8.1	0.45	3.15
3-10-1991	817	8.0	0.44	3.20	457	8.1	0.45	1.33
17-12-1991	151	9.3	0.48	0.69	160	8.9	0.47	0.51

Fig. 1 shows the energy these supplied to each system. There was a period of minimum supplementation from the middle of May until the end of June that was repeated every year of the study. Maximum supplementation occurred during the months of summer, part of autumn and the end of winter, falling slightly in November depending on how early the rains came. During the study period, supplementation was undertaken for approximately nine months, greater than the mean for the area (six months) the kind of supplementation required in years with poor weather conditions.
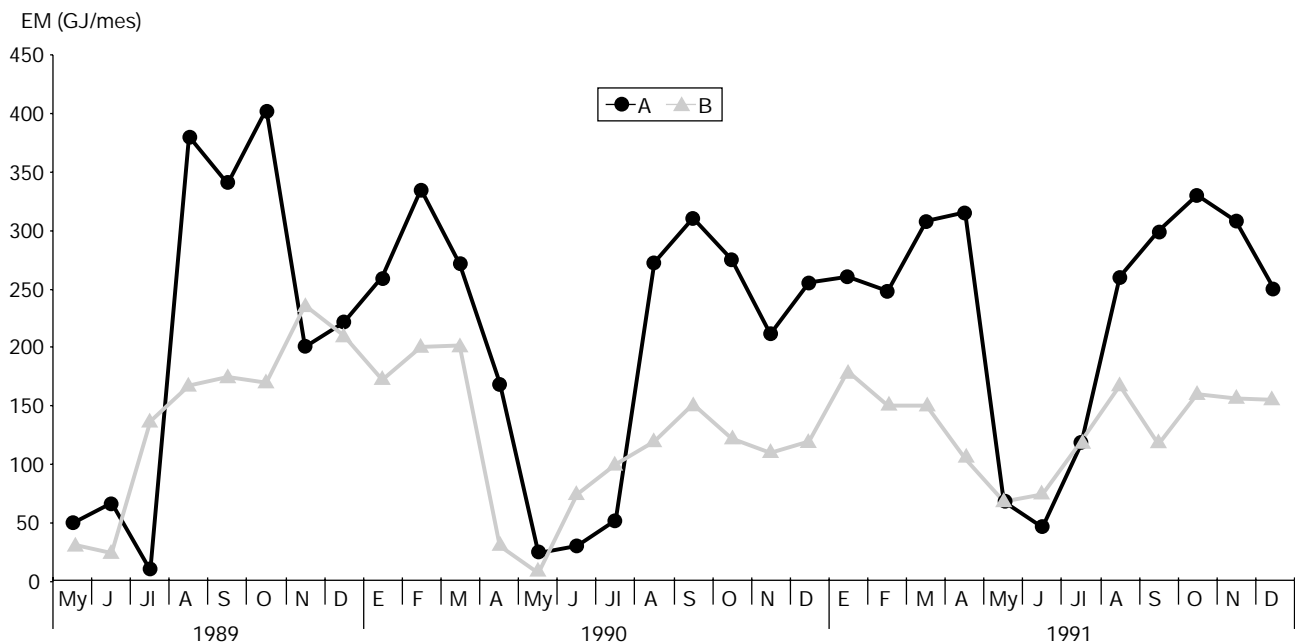
Figure 1. Monthly energy provided by supplementation (EM, GJ/mes) in 1989, 1990 and 1991 in systems A and B.

The total energy supply from the pasture, acorns, and supplementation was 9,407, 15,486 and 15,109 GJ year^{-1} for system A, and 4,928, 9,782 and 10,277 GJ year^{-1} for system B, for 1989, 1990 and 1991 respectively. The energy supplied by supplementation was 20% of the entire annual supply in 1990 and 1991.

In summary, significant differences ($P < 0.05$) were seen in pasture production between years, harvests and the low, middle and high slope position. In contrast, the chemical composition of the pasture was only influenced by the year and harvest date. In general, the RP content, DOM and ME of system A pasture were greater.

If the nutritive value of the pasture during the vegetative cycle is taken into account, the time when protein and energy supplementation is necessary is from the middle of June to the beginning of October.

Pasture production in spring provides the greatest energy input into the systems, corresponding to some 77-95% of the total production of pasture.

The metabolicity of the pasture varies between 0.43 and 0.53 values corresponding to a medium energy content at the beginning of spring and the end of autumn, and a low content over the rest of the year.

Supplementation made up 20% of the total usable energy. The greatest inputs in this respect were made between August and October and January and March, although these periods can be quite reduced depending on the arrival of the season and the criterion of the stock raiser. The parallels between these systems indicates coincidence in season, the way they are managed and climatic conditions. The results may therefore be extrapolated to the wider region.

References

BASSERY B., CAMPLING R. C.,1988. Production of temperate forages intake and digestibility using «in vitro» techniques. MARDI. Res J 16 (1), 33-42.

BELLIDO M.M., ESPEJO D.M., PLAZA G.T., 1986. Metodología para la determinación de la carga ganadera de pastos extensivos. MAPA. S.I.A. de la Junta de Extremadura, Spain. 37 pp.

CALVO C.J.C., CALVO C.G., VARGAS G.J., APARICIO T.M.A., 1997. Gestión de recursos de pastoreo y de la suplementación en sistemas adehesados. XXXVII Reunión Científica de la S.E.E.P. Sevilla-Huelva, Spain. pp. 427-432.

CORBETT J.L., 1981. Determination of the utilization of energy and nutrients by grazing animals. Forage evaluation. (Ed. J.L. Whecler and R.D. Mochrie), CSIRO, Australia, pp 191-205.

EARLY R.J., MAHGONB O., LU C.D., 2001. Energy and protein utilization for maintenance and growth in Omani ram lambs in hot climates. I. Estimates energy requirements and efficiency. J Agric Scien 136, 451-459.

GAILLARD B., 1989. Forage production in two areas of France. In: Legumes in farming system (P. Plancquaert and R. Haggar, eds), Acribia S.A, Zaragoza, Spain. pp. 105-116.

GARCIA RODRIGUEZ A., 1966. Los suelos de la provincia de Salamanca. Publicaciones IOATO del C.S.I.C. de Salamanca, Spain. 145 pp.

GARMENDIA I.J.,1965. Estudio climatológico de la provincia de Salamanca. Publicaciones de la Diputación Provincial de Salamanca, Spain. 29 pp.

GIVENS D.I., JEANNIE M., EVERINGTON ADADMON A.H., 1989. The digestibility and metabolizable energy content of grass silage and their prediction from laboratory measurements. Anim Feed Sci Tech 24, 27-43.

GUEVARA J.C., ESTEVEZ O.R., SILVA J.H., MARCH A., 1991. Adequacy of native range grasses to meet protein and energy beef cow requirements in the plain of Mendoza, Argentina. Proc. IV International Rangeland Congress. Montpellier, France, pp. 696-699.

JARRIGE R., 1980. Place of herbivores in the agricultural ecosystems. In: Digestive physiology and metabolism in ruminants. (J. Ruche Busch and P. Thivend Lancaster, eds) M. T. P. Press Limited, UK. pp. 763-823.

MARTIN POLO J.L., PRAT P.L., 1983. Mejora de suelos marginales semiáridos: Recuperación de erial a pasto. I. Respuesta a la fertilización y evolución del suelo. Anu. Cent. Edafol. Biol. Apl. Salamanca 9, 277-289.

MARTIN POLO J.L., GARCIA BELLIDO I., 1995. Calidad de los henos de zonas ganaderas de Salamanca. II. Predicción de la materia orgánica y proteína digestible y de la energía metabolizable. Invest Agr: Prod San Anim 10 (2), 121-127.

McDONALD P., EDWARDS R.A., GREENHALGH J.F.D., 1986. Nutrición Animal. Ed Acribia, Zaragoza, Spain. 518 pp.

PÉREZ C.M.E., GARCÍA C.A., GARCÍA C.B., VÁZQUEZ A.R., 1995. Patterns of aboveground herbage production and nutritional quality structure on semiarid grassland. Soil Sci Plant Anal 26 (9-10), 1323-1341.

PÉREZ C.M.E., VÁZQUEZ A.R.B., GARCÍA C.B., GARCÍA C.A., 1998. Variations in nutritional quality and biomasa production of semiarid grassland. J Range Manage 51, 570-576.

RICO M., PUERTO M.A., GÓMEZ G.J.M., 1979. Tipificación de pastizales semiáridos en función de sus especies dominantes. Pastos 9 (2), 5-15

RICO M., GARCIA C.B., PUERTO M.A., 1986. Comunidad de pastizal de dos unidades de explotación en régimen ganadero extensivo. I. Descripción de la vegetación. Melhoramento 29, 72 pp.

SUSMEL P., ESPEJO D.M., BRELURUT A., 1987. L´unité ovine mediterranéenne (U.O.M.) Symposium PHILO-ETIOS sur l´evaluation des ovins et des caprins méditerranéens. Reunion CEE-AGRIMED. Fonte Boa, Santaren, Portugal. 29 pp.

VAN SOEST P.J., MERTENS D.R., DEINIUM B., 1978. Pre-harvest factors influencing quality conserval forage. J Anim Sci 47 (3), 712-720.

VÁZQUEZ P.F., RAMOS M.S., DONCEL P.E., CASOSO-LA J.A., BALBUENA E., BLANCO J., POZO J., 2001. Aforo de Montaneras (Metodología). Departamento de Producción Forestal y Pastos. Publicaciones de la Secre-taría General Técnica. Consejería de Agricultura Comer-cio, 19 pp.

WARD J.K., DE GRACIA M., 1986. Complementary natu-re of crop animal research. Select. Proc. of Farming Systems Research Symposium. (C. Butler Flora and M. Tomececk, eds). Kansas State University, Manhattan, Kansas 66506. USA, 13 pp.