Trop. Sci. 1998, **38**, 198–205

The rumen degradability of Mongolian pastures measured *in sacco* and by *in vitro* gas production

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Abstract *Grass samples from nine pastures in Mongolia were analysed, three from the desert steppe, one from steppe, two from forest steppe and two from high mountain zones. Desert steppe and steppe zones had significantly higher hemicellulose than high mountain and forest steppe. There were no differences between pastures types within climatic zones. The nutritive value of these grasses was assessed using the* in vitro *gas production and* in sacco *techniques. There were no significant differences between zones or pastures* in vitro *or* in sacco. *There was a significant effect of season on cumulative gas production at 70 h, DMD at 70 h, protein and NDF. Data from the* in vitro *gas production and the* in sacco *techniques were compared: the correlations in the extent of degradation were generally good and both detected similar trends in pasture degradabilities over time.*

Keywords: Mongolia, pastures, *in sacco* degradability, *in vitro* gas production.

Introduction

Animal performance in Mongolia is very dependent on the quantity and quality of native pasture, since livestock may obtain as much as 90% of their annual intake from such pastures. Native grassland covers some 125.8 million ha, and there are about 2270 grass species and 600 species of other fodder plants. Rangelands occur in five regions: the high mountain and forest steppe (27%), steppe (28%) and the desert steppe and desert (45%). In the northern rangelands, where the annual rainfall is 250–300 mm, the main pastures occur in forest steppe and high mountain regions. In the latter the altitude is 2000–2400 m above sea level and the average temperature is –1.4°C. In the south, where the rainfall is 50–100 mm per annum, steppe and desert steppe are the most common, at an altitude of 1000–2000 m and with an average temperature of 3.9°C.

In Mongolia the growing season is short and is very dependent on climate, particularly rainfall. New growth in the forest steppe and steppe zones begins in mid-April, whereas elsewhere it may not begin until mid-May. Growth is often very slow, and the grazing of young grass may only be possible after 30–35 days. Livestock, therefore, consume small amounts of fresh grass in April/May along with larger amounts of senescent material. From June to September, nearly all of the intake is of fresh grass. Some grass species reach their final growth stage in August and show signs of senescence, although other grass species may continue vegetative growth till mid-September and some remain green until mid-October. Thus

Accepted 28 November 1997

Mongolian livestock may rely on senescent grass as its main feed for about 200 days. During the growing season some areas remain ungrazed to be harvested and conserved as hay or left to provide a standing forage during winter.

This paper considers the seasonal changes in composition of three pasture types from the desert steppe, one from the steppe, two from forest steppe and two from high mountain zones of Mongolia. Also the nutritive value of these grasses was assessed using *in vitro* gas production and *in sacco* to compare these techniques.

Experimental

Pasture samples were collected at the end of February and then monthly from April to October or November from desert steppe, steppe, forest steppe and high mountain areas. Samples were harvested 5 cm above ground level from a 1 m square quadrat, repeated four times for each pasture. Samples were air-dried and ground to pass through a 1 mm sieve; 90 samples were collected.

Desert steppe samples were collected 530 km south of the capital Ulaanbaatar. The average annual rainfall is about 114 mm of which 74% falls in June–August, and the annual mean temperature is 5.1°C. These pastures are used as standing forage in winter–spring. In Pasture 1 bunch grass-forb dominated. The main species are *Stipa gobica*, *S. glareosa*, *Cleistogenes squarrosa*, *Artemisia frigida*, *A. xerophytica*, *Anabasis salsa*, *Reamura soongaricum*, *Carex duriuscula*, *Caragana bungei* and *Allium polyrrhizum*. The area is used by camels, sheep and goats. In Pasture 2, *Allium polyrrhizum* and *Stipa gobicum* dominated, and other common species are *Caragane bungie*, *Cleistogenes soongaricum*, *Convolvulus ammanii* and *Iris tenifolia*. The area is used for sheep and goats. In Pasture 3, the main species are xerophilous and saline shrubs, with *Haloxylon ammodendron*, *Artemisia xerophytica* and *Reamura soongaricum* dominant. The area is grazed mostly by camels.

Steppe samples were collected 350–400 km east of Ulaanbaatar, where the average altitude is 600–750 m above sea level. The principal pasture species are *Stipa caphillata* and *Cleistogenes squarrosa*, with also *Agropyron cristatum*, *Koeleria macrantha*, *Poa botryodes* and *Leymus chinensis*.

Forest steppe samples were collected 67 km north of Ulaanbaatar. In Pasture 1 grass-forb dominated, with the main species *Stipa krylovii*, *Agropyron cristatum*, *Poa botryoides*, *Leymus chinensis*, *Artemisia frigida* and *Arenaria capillaris*. The most common sedge species were *Carex duriuscula*, *C. korshinskyi* and *C. pediformis*. New growth here is from 10 April onwards and tillering is around 15–30 May. Pasture 2 is a meadow community containing mesophyte grasses which require comparatively high moisture. The bunch grasses *Leymus chinensis*, *Bromus inermis*, *Agrostis mongolica* and *Poa attenuatta* predominate. The main forbs are *Valerina officinalis*, *Thalictrum simplex*, *Geranium pratense* and *Sanguisorba officinalis*. New growth occurs at the beginning of May and grazing is possible after about 30 days. Tillering by loose bunch and rhizomatous grasses occurs around 15–30 June. In September most of the pasture species have senesced and by October the plants are completely dry: what remains is used as a standing crop for animals in winter–spring.

High mountain pastures are mostly used as grazing for horses and yaks, which may derive as much as 97–98% of their intake from pasture. The sampling sites were 300 km south-west of Ulaanbaatar. Pasture 1 was at 2100–2200 m and is south facing. Ground coverage was 60–70% in late July or mid-August and the grass 4–6 cm high. *Festuca lenensis* dominated the pasture, and other species were *Helictotrichon schellianum*, *Koeleria cristata*, *Agropyron cristatum*, *Artemisia commutate*, *Arenaria capillaris*, *Artemisia glauca* and *Pulsatilla turzaninovii*. This pasture is heavily overgrazed by large and small livestock. Pasture 2 was an alpine meadow at 2500–2600 m on the north slope of the mountain. Ground coverage was 65–75% in mid-summer and the grass was 20–22 cm high. The main forage plant is *Kobresia bellardii*, with *Polygonum viviparum*, *Helictotrichon mongolicum*, *Oxytropis kuznecovii*, *Conpenula turzaninovii*, *Sanqusorba officinalis*, *Vicia multicaulis*, *Aster alpinus*, *Scorzonera radiata*, *Pedicularis oederi*, *P. rubens*, *Thalictrum alpinum*, *Carex melanantha*, *Crepis chrysantha* and *Androsance chamajasme*. These species grow in less than 70 days. *K. bellardii* is a very good standing forage for livestock in winter.

Analysis

Samples were analysed for dry matter (DM), organic matter (OM), crude protein (CP), ash, acid detergent fibre (ADF) and neutral detergent fibre (NDF) by AOAC (1980) methods. Hemicellulose was defined as NDF – ADF.

In sacco rumen degradability was determined on 51 samples from high mountain and forest steppe pastures by the method of Ørskov and McDonald (1979). Degradation of pasture samples was assessed at 0, 6, 12, 24, 48, 72 and 96 h using duplicated bags for each time. Dry matter disappearance at 96 h (DMD96) was taken as a measure of the degradation.

In vitro gas production and dry matter disappearance were determined on all 90 samples using the method of Theodorou *et al.* (1994). Cumulative gas production was measured using 125 ml serum bottles containing 1 g sample, 90 ml nitrogen-rich medium and 5 ml inoculum prepared from strained rumen liquor. Gas volumes were measured at 3, 6, 8, 12, 16, 20, 24, 28, 33, 39, 45, 52, 60 and 70 h. At the end of the incubation the residues were recovered by filtration and the dry matter disappearance calculated. Cumulative gas production at 70 h (CG70) and *in vitro* dry matter disappearance at 70 h (DMD70) were taken as measures of degradation.

Computation of data and statistical analysis

In sacco DMD and gas production kinetics from 12 h incubation were described using the exponential equation $p = a + b(1 - e^{-ct})$ (McDonald 1981), where p is the DMD or gas production at time t, (a+b) was the potential DMD or gas production, c was the rate of DMD or gas production (a, b and c are constants). Statistical analysis was carried out on gas production data, *in sacco* data and chemical parameters using the REML technique. Each variable was analysed for the effect of zone and season. Relationships between *in sacco* DMD and gas production data were investigated using regression analysis.

Results

There were no significant differences between the four zones in protein content, organic matter or neutral detergent fibre (Table 1). For hemicellulose, desert steppe and steppe pastures had significantly (P>0.01) higher values than high mountain and forest steppe pastures. There were no significant differences between the four zones in *in vitro* gas parameters or *in sacco* parameters, or in chemical composition, *in vitro* gas production and *in sacco* degradability between pasture types within climatic zones (not shown in table).

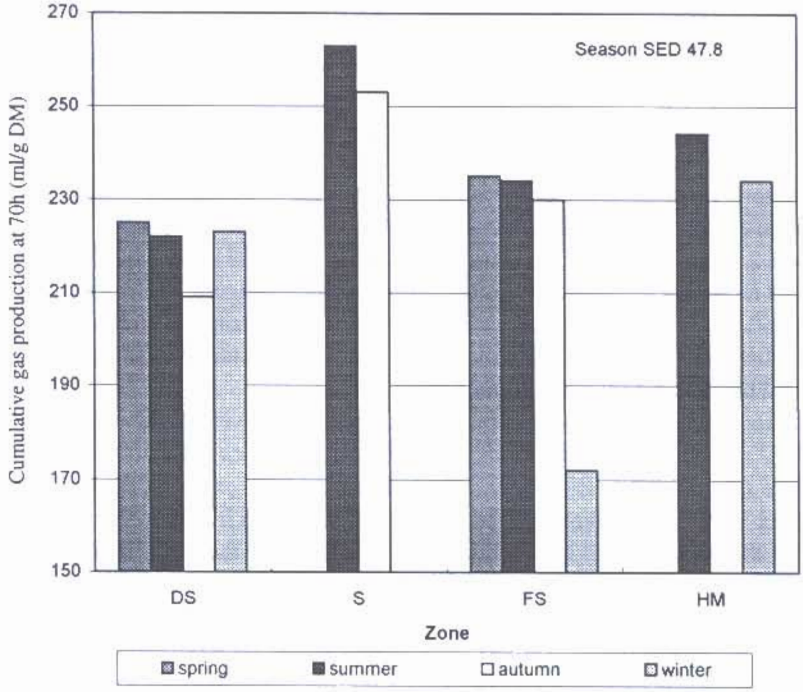
There was a significant effect of season on CG70 (P>0.003) and DMD70 (P>0.0001), with a marked reduction in both in the forest steppe in winter (Figure 1). Season had a significant effect (P>0.0001) on protein content: it was highest for all zones in summer and declined in autumn and winter. The neutral detergent fibre was also affected (P>0.0001), being lowest in summer and highest in winter in all four zones.

The gas production indicators of the extent of degradation were highly correlated (CG70 vs DMD70, $R^2 = 0.76$; CG70 vs gas pool, $R^2 = 0.67$), but *in sacco* indicators were less highly correlated (a + b vs DMD96, $R^2 = 0.60$). The indicators of the extent of degradation for the two techniques were highly correlated: for *in sacco* DMD at 96 h and *in vitro* DMD at 70 h, $R^2 = 0.72$). *In sacco* (a + b) and gas production CG70, probably the most reliable measures of the extent of degradation from the two techniques, were correlated with $R^2 = 0.59$, closely similar to the (a + b) and DMD96 correlation of the two *in sacco* parameters. The correlation between DMD at 96 h *in sacco* and gas pool size (constant b) was particularly poor ($R^2 = 0.12$), possibly reflecting experimental errors in measuring DMD96 and errors in gas pool size arising from systematic mis-fitting between the exponential equation and the experimental data. The rate constants (c) were poorly correlated ($R^2 = 0.26$. There was a very strong correlation between the two gas production runs for cumulative gas production at 70 h ($R^2 = 0.92$), demonstrating the high degree of reproducibility achieved.

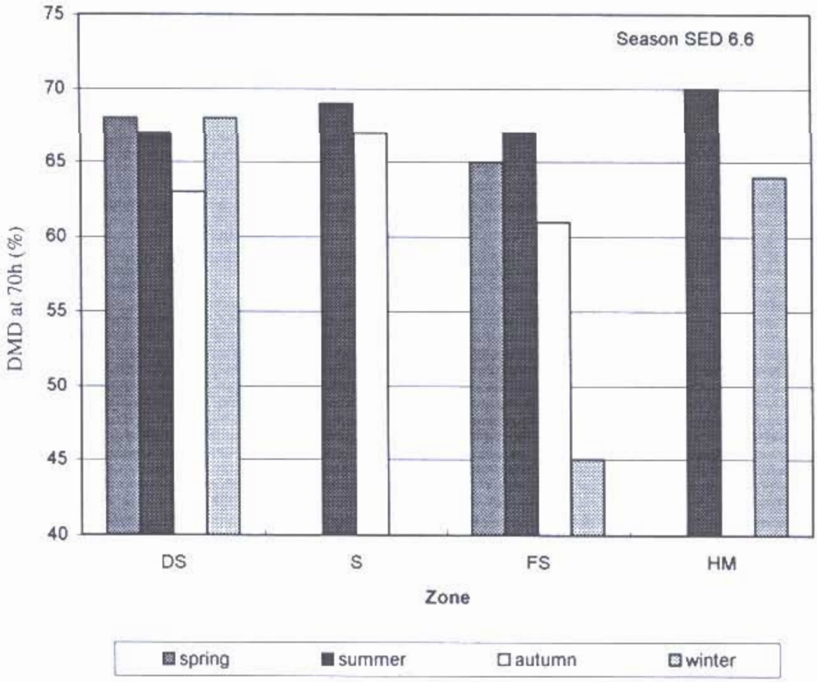
Table 1. Analysis and degradability of pastures

	Desert steppe	Steppe	Forest steppe	High mountain	EMS	Sig
OM (%)	85.6	94.8	90.4	90.7	38.62	NS
CP (%)	12.05	9.19	11.51	10.88	1.152	NS
NDF (%)	62.5	63.9	59.4	60.1	9.349	NS
ADF (%)	38.05	38.11	43.92	42.06	4.099	NS
HEM (%)	24.41	25.81	15.51	18.05	4.053	0.011
In vitro gas production						
CG70 (ml/g)	221	262	229	243	1516	NS
DMD70 (%)	66.8	68.4	63.4	69.4	0.221	NS
OMD70 (%)	65.9	68	63.8	70.3	0.432	NS
(a + b)	271	328	287	309	2616	NS
c	0.0396	0.0309	0.0379	0.0388	0.00004	NS
In sacco degradation						
a			23.3	20.3	7.305	NS
b			50.9	57.4	11.54	NS
(a + b)			74.1	77.7	16.08	NS
c			0.0395	0.0378	0.00003	NS
DMD96 (%)			72.4	74.8	11.64	NS

(a)

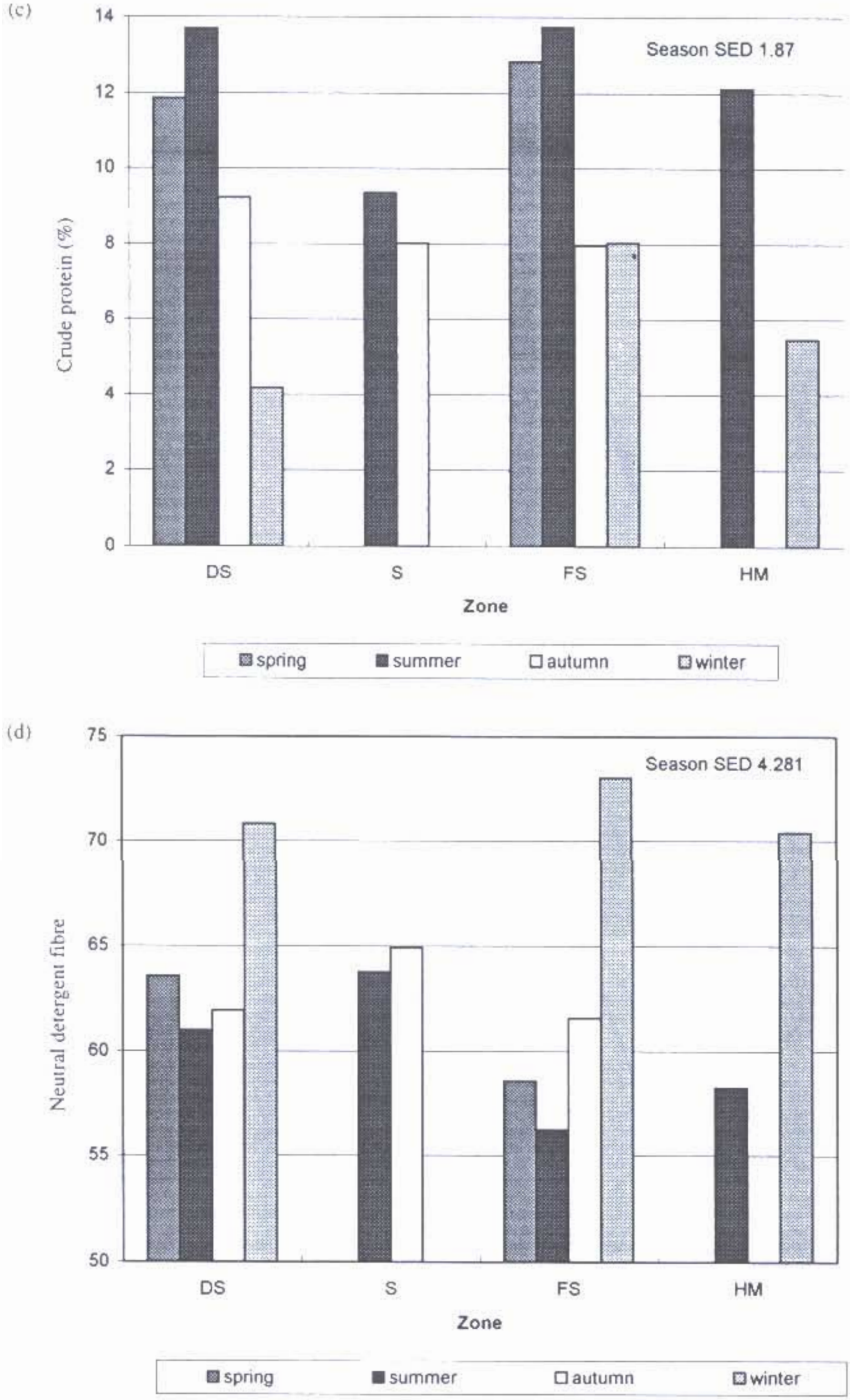


(b)



(contd)

Figure 1. Seasonal changes in (a) CG70 (ml/g), (b) DMD70 (%), (c) protein (%) and (d) NDF (%) in pastures from desert steppe (DS), steppe (S), forest steppe (FS) and high mountain (HM) zones



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Discussion and conclusion

There were no significant differences in chemical composition between the pastures from the four zones apart from the levels of hemicellulose, for which high mountain and forest steppe pastures had lower values than steppe and desert steppe. When the pasture samples were analysed *in vitro* and *in sacco* there were no significant differences between the four zones. As expected, the season had an effect on gas production parameters, protein and NDF.

The correlations in the extent of degradation as measured by the two techniques were generally good, as observed by Blummel and Ørskov (1993) in work with cereal straws. The techniques detected similar trends in pasture degradability with time.

Acknowledgement

We thank the Department for International Development for financial support.

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