Dietary selection of sheep grazing the semi-arid grasslands of Inner Mongolia, China at different grazing intensities

A. Schiborra¹, M. Gierus¹, H. W. Wan¹, T. Glindemann², C. J. Wang²,³, A. Susenbeth² and F. Taube¹

¹ Institute of Crop Science and Plant Breeding, Grassland and Forage Science/Organic Agriculture, Christian-Albrechts-University, Kiel, Germany,
² Institute of Animal Nutrition and Physiology, Christian-Albrechts-University, Kiel, Germany, and
³ College of Ecology and Environment, Inner Mongolia Agricultural University, Huhhot, China

Introduction

Grazing ruminants actively select their diet from herbage on offer (Arnold, 1960; Ayantunde et al., 1999). Two main factors were identified which influence dietary selection of grazing ruminants. Firstly, the amount of herbage on offer influences the degree of dietary selection. When herbage on offer is abundant, grazing ruminants are able to select their diet, but when herbage on offer is limited, dietary selection is also limited (Hamilton et al., 1973; Broom and Arnold, 1986). At low availability of herbage on offer, grazing animals are forced to ingest low quality sward components in an attempt to meet their nutritional requirements (Milne et al., 1979; Animut et al., 2005).

Secondly, the degree of dietary selection depends on the quality of herbage on offer, which varies with location, season and utilization intensity (Minson, 1990). Especially when the quality of herbage on offer is low, grazing ruminants intensively select their diet to improve the quality of herbage ingested (Grant et al., 1982; Bartolomé et al., 1998). Dietary selection may occur against certain plant species,
certain plant organs and against non-green plant material (Arnold, 1960; Chacon and Stobbs, 1976). These observations were mainly reported for temperate grasslands, but similar results were obtained in semi-arid grasslands (Pinchak et al., 1990).

Measuring dietary selection of free-ranging ruminants has always been a challenge to animal scientists, but several methods were developed as reviewed by Gordon (1995). In this study, the differences in quality between herbage on offer and herbage ingested were used to assess the degree of dietary selection of grazing sheep. The criterion used to describe herbage quality was the organic matter digestibility (OMD). It was hypothesized that the difference in OMD between herbage on offer and herbage ingested is high, when grazing animals actively select against low quality herbage. The difference will be low, when the animals are less selective or do not select their diet at all. Therefore, we expect that ruminants grazing grasslands of low nutritional value intensively select their diet when herbage on offer is abundant, but when herbage on offer is limited, dietary selection is also limited. The objective of this study was to investigate the selection behaviour of sheep (Ovis aries) grazing natural grassland in Inner Mongolia, China using the difference between OMD of herbage on offer and herbage ingested as indicator for dietary selection.

Materials and methods

Study site, experimental design and conditions

The experiment was carried out near the Inner Mongolia Ecosystem Research Station (IMGERS) operated by the Institute of Botany, Chinese Academy of Sciences, Beijing. IMGERS is located in the Xilin River Basin, Inner Mongolia Autonomous Region, China (116°42'E, 43°38'N) at an altitude of approximately 1200 m. The climate is semi-arid, characterized by significant seasonal and inter-annual precipitation variability. Mean annual temperature is 0.7 °C. Mean annual precipitation is 346 mm, of which 85% are occurring from May through September. In 2005, the mean annual temperature was 0.1 °C and mean annual precipitation amounted to only 166 mm. The vegetation period is approximately 150 days long, only 100–135 days are frost-free. The vegetation is dominated by grasses, which comprise more than 90% of the total biomass. Some forb species are also found, but no shrubs or trees. The perennial bunchgrass Stipa grandis P. Smirn. and the rhizomatous Leymus chinensis (Trin.) Tsvelev are the dominant grass species, both belonging to the C3 photosynthesis type. Together these grasses account for approximately two-thirds of the dry matter (DM) yield of the experimental area.

In a grazing experiment, six grazing intensities (1.5, 3.0, 4.5, 6.0, 7.5 and 9.0 sheep/ha) were compared in terms of their impact on the steppe ecosystem providing decreasing amounts of herbage on offer, so that the hypothesis could be tested. Wang et al. (1999) defined an optimal stocking rate of 3 sheep/ha for a similar, but less productive herbage sward. Therefore, the grazing intensities chosen can be classified as light (1.5 and 3.0 sheep/ha), moderate (4.5 and 6.0 sheep/ha) and heavy (7.5 and 9.0 sheep/ha) grazing intensities. The grazing experiment was performed as a randomized block-design with two replicates and was initiated in June 2005 on an intact grassland area without signs of severe degradation. Sheep are the most frequent livestock grazing the natural grassland in Inner Mongolia. Groups of six to 18 sheep from a local fat-tailed breed grazed 12 paddocks (six grazing intensities × two replicates) continuously from the beginning of June through end of September. The female, non-lactating and non-pregnant sheep had an average body weight of 31.6 kg (SD ± 4.8) at the beginning of the experiment. Sheep were not supplemented, had free access to water and minerals and were treated against endoparasites with disophenol prior to the start of the experiment.

Herbage sampling and analysis

Herbage on offer was defined as standing biomass cut to 1 cm stubble height, assuming this to be the minimum bite height of a sheep under restricted but not starving conditions. Sampling periods were five consecutive days at the beginning of July, August and September when faecal samples were taken. The samples of herbage on offer were taken on 1 day during each of the sampling periods. In each paddock, one pooled sample was obtained from three sub-samples, taken from 0.5 m² (0.25 × 2 m) sized transects at previously defined representative areas. A sub-sample (approximately 40–50 g) was taken from the pooled sample to separate green (living) herbage from dead herbage. All samples were dried at 60 °C for 24 h in a forced-air oven and dry weight was determined. The dried bulk samples were ground with a cyclotec mill (Foss Tecator, Rellingen, Germany) to pass through a 1-mm screen. Near-Infrared-Spectroscopy (NIRS) was used to estimate the DM, ash, crude protein (CP), neutral detergent fibre (NDF), acid
detergent fibre (ADF) and acid detergent lignin (ADL) content of the herbage samples. The laboratory analyses were carried out on calibration and validation sub-sets of herbage bulk samples, which were randomly chosen by the software nirs 2 by Infrasoft International® (ISI, Port Mathilda, PA, USA). Residual DM content was determined by drying at 105 °C to constant dry weight, and organic matter (OM) content was calculated after determination of ash by incineration of the dry sample at 550 °C over night. The CP content was calculated from the N content (CP = N × 6.25), which was analysed by a C/N-Analyzer (vario Max CN; Elementar Analysensysteme, Hanau, Germany). The contents of NDF, ADF and ADL were analysed sequentially without using decalin or sodium sulphite by a modification of the method of Van Soest et al. (1991) using a semi-automated Ankom 200 Fiber Analyzer (Ankom Technology, Macedon, NY, USA). The NDF and ADF values are expressed with residual ash.

Digestibility of herbage ingested

The OMD of herbage ingested was estimated from faecal N concentration. Six sheep per paddock were chosen as tester animals and faeces samples were taken as grab samples from their rectum regularly in the morning on five consecutive days in each sampling period. The faeces samples of each sheep were pooled, frozen and homogenized to analyse the N content by the Micro-Kjeldahl procedure (for more details see Glindemann, 2009). The ash content of the dried faeces samples was determined by ashing a sub-sample (1 g) at 550 °C over night. Equation 1 was used to estimate the OMD of herbage ingested from faecal-N (FOMD) (Wang et al., 2008).

\[
\text{FOMD} \, (\%) = 89.9 - 64.4^\circ \exp(-0.5774^\circ \text{faecal CP} \quad \text{[g/kg OM]} / 100) 
\]

(1)

The non-linear mixed model procedure (SAS Institute, Cary, NC, USA) was used to derive eqn (1) from an extensive data set containing 721 values from in vivo experiments, with mainly grass and legume silages and hay. The hay diets were partly supplemented with concentrates at levels below 400 g/kg DM. Also results obtained from feeding trials in Inner Mongolia testing local hays were included. The mean in vivo OMD of the tested feedstuffs was 66.5%, ranging from 41% to 83%. The mean bias between predicted and in vivo measured OMD was −1.4%, with a standard error of 0.17.

Digestibility of herbage on offer

The OMD of herbage on offer was estimated from the gas production, CP and ash content. The gas production was determined by the in vitro method Hohenheim gas test (HGT) (Menke et al., 1979), which was performed at the University of Kiel and conducted according to the specifications of Menke and Steingass (1988). The only modification was that rumen fluid was collected approximately 90 min after morning feeding from wethers, because it was impossible to acquire enough rumen fluid before morning feeding. This did not influence the results decisively, as the benchmark values given by Menke and Steingass (1988) were within the limits. The wethers were fed twice daily at 07:00 and 17:00 hours, getting 1.62 kg DM of hay and 1.23 kg DM of concentrate divided in two equal meals. The average weight of the wethers was 90 kg. The gas production after 24 h was corrected for control (without feed sample) and for benchmark values of standard feed provided by the University of Hohenheim. The digestible OM from gas production (GOMD) was estimated by eqn (2) (Menke and Steingass, 1988):

\[
\text{GOMD} \, (\%) = 16.49 + 0.9042^\circ \text{GP} + 0.0492^\circ \text{CP} + 0.0387^\circ \text{ash} 
\]

(2)

[GP (gas production): ml/200 mg DM in 24 h, CP and ash: g/kg DM].

The equation was derived from a regression including data from 100 roughages (50% hays, 25% straws, 25% grass cobs) tested in in vivo digestibility trials ranging from 30 to 76% in OMD. The relative error (RMSE) was 4.3% with \( r^2 = 0.93 \).

To define an indicator for the degree of dietary selection, the difference between FOMD and GOMD was calculated. Positive differences indicate dietary selection against poorly digestible herbage on offer, while negative differences would indicate selection against higher digestible herbage offered.

Statistical analysis

Digestibility values obtained from faecal-N method and HGT were independently subjected to an ANOVA using the mixed procedure of sas®9 (SAS Institute), including ‘block’, ‘grazing intensity’ (I), ‘sampling period’ (P) and the interaction ‘I × P’ as fixed factors. The three periods were considered as repeated measurements. With significant F-value (p < 0.05), mean values were tested with Student’s t-test and
probabilities corrected by Bonferroni–Holm test (Horn and Vollandt, 1995).

In addition, GOMD was tested against FOMD using the differences between FOMD and GOMD with the same model as mentioned before. With the Student’s t-test, estimates of the difference between FOMD and GOMD were tested against zero.

Results

Herbage on offer

The factors ‘grazing intensity’ and ‘sampling period’ were significant for herbage on offer, but not the interaction ‘I × P’. Herbage on offer decreased with increasing grazing intensity (Table 1). However, the differences between grazing intensities were only significant between 1.5 and 7.5 sheep/ha. Mean herbage on offer in July and August was 104 and 100 g DM/m² respectively. In September, herbage on offer decreased to 71 g DM/m². The green herbage proportion of herbage on offer was not influenced by grazing intensity, but green herbage proportion decreased from 95% in July to 82% and 79% in August and September respectively.

The quality of herbage on offer was not different between grazing intensities, but some quality variables changed in the course of the growing season (Table 2). The CP content decreased from 98 to 88 and 77 g/kg DM from July to September. The ADF and ADL contents increased from July to September, whereas NDF did not change during this time.

Digestibility estimation

The experimental factor ‘sampling period’ was significant for FOMD and GOMD, whereas the factor ‘grazing intensity’ and the interaction ‘I × P’ were not. Results of digestibility estimations are summarized in Table 3. Grazing intensity did not affect FOMD and GOMD. The sampling period, however, had a significant influence on both FOMD and GOMD, i.e. the digestibility decreased as the vegetation period progressed. The mean FOMD decreased from 56.5% in July to 55.6% and 53.8% in August and September, respectively, whereas the mean GOMD ranged between 60.5% in July and 52.9% in September.

For each sampling period, the gradients of FOMD and GOMD over the six grazing intensities are demonstrated in Fig. 1, and the statistical estimates are given in Table 4.

In July, GOMD differed from FOMD by an average 4 percentage units. In August, GOMD could not be separated statistically from FOMD, whereas in September GOMD differed from FOMD with only +1 percentage unit. To evaluate if GOMD differs from FOMD irrespective of the sampling period, estimates were tested over all grazing intensities and all sampling periods. The statistical analysis showed that

---

**Table 1** Herbage on offer and proportion of green herbage in July, August and September 2005

<table>
<thead>
<tr>
<th>(Sheep/ha)</th>
<th>Herbage on offer (g DM/m²)</th>
<th>Green herbage* (% of herbage on offer)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Herbage on offer</td>
<td>Green herbage</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>August</td>
</tr>
<tr>
<td>1.5</td>
<td>146</td>
<td>170</td>
</tr>
<tr>
<td>3.0</td>
<td>121</td>
<td>126</td>
</tr>
<tr>
<td>4.5</td>
<td>100</td>
<td>72</td>
</tr>
<tr>
<td>6.0</td>
<td>111</td>
<td>109</td>
</tr>
<tr>
<td>7.5</td>
<td>59</td>
<td>66</td>
</tr>
<tr>
<td>9.0</td>
<td>89</td>
<td>61</td>
</tr>
<tr>
<td>Mean</td>
<td>104&lt;sup&gt;a&lt;/sup&gt;</td>
<td>100&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SE</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

Superscript lower case letters indicate significant (p < 0.05) differences between grazing intensities.

---

**Table 2** Chemical composition of herbage on offer in July, August and September 2005*

<table>
<thead>
<tr>
<th></th>
<th>OM (g/kg DM)</th>
<th>CP (g/kg DM)</th>
<th>NDF (g/kg DM)</th>
<th>ADF (g/kg DM)</th>
<th>ADL (g/kg DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>945&lt;sup&gt;d&lt;/sup&gt;</td>
<td>98&lt;sup&gt;a&lt;/sup&gt;</td>
<td>730</td>
<td>340&lt;sup&gt;b&lt;/sup&gt;</td>
<td>41&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>August</td>
<td>944&lt;sup&gt;b&lt;/sup&gt;</td>
<td>88&lt;sup&gt;b&lt;/sup&gt;</td>
<td>726</td>
<td>348&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>50&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>September</td>
<td>945&lt;sup&gt;a&lt;/sup&gt;</td>
<td>77&lt;sup&gt;c&lt;/sup&gt;</td>
<td>723</td>
<td>353&lt;sup&gt;a&lt;/sup&gt;</td>
<td>54&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SE</td>
<td>1.4</td>
<td>2.8</td>
<td>3.2</td>
<td>2.7</td>
<td>0.7</td>
</tr>
</tbody>
</table>

OM, organic matter; CP, crude protein; NDF, neutral detergent fibre; ADF, acid detergent fibre; ADL, acid detergent lignin.

Superscript letters indicate significant (p < 0.05) differences between sampling periods.

*n = 12 for each quality variable within sampling period.
Table 3  Organic matter digestibility (%) estimated from faecal N concentration (FOMD) and Hohenheim gas test (GOMD) in July, August and September 2005

<table>
<thead>
<tr>
<th>Grazing intensity (sheep/ha)</th>
<th>1.5</th>
<th>3.0</th>
<th>4.5</th>
<th>6.0</th>
<th>7.5</th>
<th>9.0</th>
<th>Mean</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOMD (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>58.0</td>
<td>58.2</td>
<td>56.5</td>
<td>55.8</td>
<td>54.9</td>
<td>55.9</td>
<td>56.5</td>
<td>0.4</td>
</tr>
<tr>
<td>August</td>
<td>57.5</td>
<td>56.8</td>
<td>55.3</td>
<td>55.4</td>
<td>54.7</td>
<td>54.2</td>
<td>55.6</td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>56.4</td>
<td>54.6</td>
<td>54.0</td>
<td>53.1</td>
<td>53.0</td>
<td>51.9</td>
<td>53.8</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>57.3</td>
<td>56.5</td>
<td>55.2</td>
<td>54.7</td>
<td>54.2</td>
<td>54.0</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>0.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GOMD (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>61.3</td>
<td>59.7</td>
<td>60.1</td>
<td>60.9</td>
<td>60.6</td>
<td>60.4</td>
<td>60.5</td>
<td>0.4</td>
</tr>
<tr>
<td>August</td>
<td>57.5</td>
<td>55.9</td>
<td>56.5</td>
<td>56.2</td>
<td>55.1</td>
<td>54.7</td>
<td>56.0</td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>53.7</td>
<td>54.6</td>
<td>53.3</td>
<td>53.4</td>
<td>51.7</td>
<td>50.5</td>
<td>52.9</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>57.5</td>
<td>56.7</td>
<td>56.6</td>
<td>56.9</td>
<td>55.8</td>
<td>55.2</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>0.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Superscript lower case letters indicate significant (p < 0.05) differences between grazing intensities within methods.
Superscript upper case letters indicate significant (p < 0.05) differences between sampling periods within methods.

GOMD differed from FOMD by on average −1 percentage units over all sampling periods (Table 4).

Discussion

The influence of herbage availability on dietary selection of sheep grazing semi-arid grasslands of low nutritional value was examined in this study. Variation in the amount of herbage offered was provided by a grazing experiment. Six different grazing intensities were established, resulting in abundant herbage on offer in low grazing intensities and gradually limited amounts of herbage on offer in increasing grazing intensities (Table 1). Although there was only a difference between 1.5 and 7.5 sheep/ha, decreasing amounts of herbage on offer with increasing grazing intensity were observed. The lack of clear significance between grazing intensities can be attributed to the heterogeneity in herbage production within the experimental area, which was especially high in this first experimental year.

Nitrogen was used as faecal index to determine the OMD of herbage ingested. The faecal-N method is a well-established and widely used technique, which is documented in several studies (Lancaster, 1949; Corbett, 1960; Thomas and Campling, 1976; Schmidt and Jentsch, 1994; Schmidt et al., 1999; Boval et al., 2003; Lukas et al., 2005; Schlecht and Susenbeth, 2006). It is especially valuable for the determination of OMD in grazing experiments, where the OMD of actually ingested feed cannot be measured directly. The majority of the authors cited above has successfully used this method. Difficulties and restrictions were indicated, e.g. the application of equations to selected feeds only (Greenhalgh and Corbett, 1960; Boval et al., 2003) or the influence of herbage growth stage on OMD in long-term experiments (Minson and Kemp, 1961; Schmidt et al., 1999). The equation used here to estimate the OMD of herbage ingested was derived from an extensive data pool (n = 721). The equation is therefore generally applicable to a wide range of different forages and different forage qualities common in sheep
roughages with high fibre contents (Blümmel and Ørskov, 1993; Khazaal et al., 1995). Like for FOMD, no significant differences between the grazing intensities were indicated for GOMD (Table 3). In contrast to FOMD, only minor differences between the grazing intensities were expected for GOMD. As demonstrated in Table 2, the quality of herbage on offer did not differ between the grazing intensities, only between sampling periods, what can be attributed to ageing processes of the herbage plants (Buxton et al., 1996).

In July, the difference between FOMD and GOMD, which served as indicator for dietary selection, was approximately −4 percentage units, whereas in August and September FOMD and GOMD corresponded very well in the OMD estimations over all grazing intensities (Fig. 1 and Table 4). The differences between FOMD and GOMD were not significant in August and only small (<1 percentage unit) in September, confirming the above discussed observations. The negative difference in July is difficult to reconcile with the findings in August and September. It is unlikely that the sheep have preferentially ingested less digestible material. However, the observed difference falls within the range of error estimated for the equation used here (Menke and Steingass, 1988). Considering the methodological aspects of HGT, a possible influence of rumen fluid quality was avoided by taking the fluid from the same donor animals, which were fed and housed under standardized conditions, for each HGT run. According to the instructions of Menke and Steingass (1988), two standard feedstuffs (hay, concentrate) were included to correct the gas production for possible differences in rumen fluid quality. During analysis, the samples were randomly chosen and six times replicated on two different days, so that the influence of rumen fluid quality was the same for all sampling periods. Another possibility can be found in the sampling procedure of herbage on offer. Litter spread on the ground was not included, as only standing biomass was sampled. If the sheep have ingested this very low quality material in July, the FOMD decreased, whereas there was no effect on GOMD. Considering the amount of herbage on offer in July and also the high proportion of green herbage on offer during this period (Table 1), it is unlikely that the sheep have ingested litter.

The results obtained in August and September suggest that the sheep did not select their diet from herbage on offer. This implication is further supported by the results obtained for the green herbage proportion of herbage on offer (Table 1). The green herbage proportion was not significantly influenced by grazing intensity. This means the amount of green herbage on offer did not differ between grazing intensities and sheep were offered the same proportion of green herbage mass in relation to total herbage on offer regardless of the grazing intensity. This was observed in all three periods, although the green herbage proportion decreased from July to September. The quality of herbage ingested is closely related to the proportion of green herbage on offer, which was found to be decreasing when total herbage on offer was reduced (Hamilton et al., 1973). Jung and Sahlé (1989) observed less green herbage on offer in an intensively grazed sward, whereas in a less intensively grazed sward the green herbage proportion of herbage on offer was higher and therefore the OMD of herbage ingested by sheep. This was attributed to the superior chances to select higher digestible green herbage in the low grazing intensity. From all the above discussed results, it can

Table 4: Statistical analysis of differences between organic matter digestibilities (%) estimated from faecal N concentration (FOMD) and Hohenheim gas test (GOMD), tested against zero

<table>
<thead>
<tr>
<th>Sampling period</th>
<th>FOMD</th>
<th>GOMD</th>
<th>FOMD – GOMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>56.52</td>
<td>60.50</td>
<td>-3.98***</td>
</tr>
<tr>
<td>August</td>
<td>55.63</td>
<td>56.00</td>
<td>-0.37**</td>
</tr>
<tr>
<td>September</td>
<td>53.82</td>
<td>52.86</td>
<td>0.96*</td>
</tr>
<tr>
<td>SE</td>
<td>0.75</td>
<td>0.76</td>
<td>0.42</td>
</tr>
<tr>
<td>Mean</td>
<td>55.33</td>
<td>56.45</td>
<td>-1.13**</td>
</tr>
<tr>
<td>SE</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Differences are significantly different from zero: *p < 0.05, **p < 0.01, ***p < 0.001.
Table 5 Chemical composition of Stipa grandis' and Leymus chinensis' vertical layers in July 2005

<table>
<thead>
<tr>
<th>Layer (cm)</th>
<th>Stipa grandis (g kg/DM)</th>
<th>Leymus chinensis (g kg/DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CP</td>
<td>NDF</td>
</tr>
<tr>
<td>&gt;21†</td>
<td>95.6abc</td>
<td>706.4a</td>
</tr>
<tr>
<td>17–21</td>
<td>102.5a</td>
<td>720.2a</td>
</tr>
<tr>
<td>12–16</td>
<td>102.4a</td>
<td>736.6a</td>
</tr>
<tr>
<td>7–11</td>
<td>100.4a</td>
<td>749.2a</td>
</tr>
<tr>
<td>1–6</td>
<td>82.6a</td>
<td>765.9a</td>
</tr>
<tr>
<td>SE</td>
<td>0.9</td>
<td>2.4</td>
</tr>
</tbody>
</table>

CP, crude protein; NDF, neutral detergent fibre; ADL, acid detergent lignin.

Superscript letters indicate significant differences (p < 0.05) between layers within sampling period.

*Data from Schiborra (2007).
†Leymus chinensis plants were smaller than 21 cm.

be concluded that the sheep did not, or to a non-detectable extend select their diet from herbage on offer regardless of the grazing intensity. Therefore, the hypothesis has to be rejected for this study. No differences in dietary selection in relation to herbage availability were observed in 2005.

One possible explanation for reduced dietary selection is that the composition of the sward is rather homogenous (Arnold, 1981). This is unlikely to occur in multi-species grassland swards which are continuously grazed. It has been widely demonstrated that grazing results in patchy structures of grazed and ungrazed areas, resulting in areas of high and low herbage quality (Bakker et al., 1983; Willms et al., 1988). In this study, grazing started in mid-June 2005 with an average of 80 g DM/m² herbage offered to all grazing sheep. Information about the vertical quality structure of the two dominant species S. grandis and L. chinensis is available (Table 5). An additional cutting frequency experiment was carried out in the same location as the described grazing experiment (Schiborra et al., 2006). Together the two dominant species accounted for approximately 65% of herbage on offer. The samples for the determination of the vertical quality structure were taken in July 2005 from plots cut only once in the end of the vegetation period. The grass plants were divided into 5-cm layers, from 1 cm above ground level to the top. The CP, NDF and ADL contents were determined for each layer as described for herbage on offer. L. chinensis was generally of higher quality than S. grandis. S. grandis increased significantly in quality from the bottom up, as it is expected for grasses and provides the chance to select plant parts of higher quality (Wilkinson et al., 1970; Delagarde et al., 2000). Leymus chinensis however, the most abundant species (>35% of total herbage DM offered), indicated only minor differences in its vertical quality structure (Table 5). Particularly, the ADL content, which is strongly negatively correlated with OMD (Minson, 1982; Van Soest, 1994), did not vary between the most productive layers. L. chinensis is highly palatable and favoured against S. grandis by grazing animals (Wang et al., 2001), so that the proportion of L. chinensis ingested is higher than the proportion of S. grandis. Furthermore, the year 2005 was extremely dry. Herbage productivity was halved and the water limitation resulted in reduced dynamics in herbage quality development. Especially, the usually positive influence of defoliation on herbage quality was inhibited (Schiborra, 2007). From this it can be argued that the grazing sheep were constrained in their selective behaviour, due to the fact that the quality structure of herbage on offer was rather homogenous in 2005.

Conclusions

Dietary selection was not observed in 2005 in the presented grazing experiment conducted in the semi-arid steppe of Inner Mongolia, China. Against the stated hypothesis, herbage availability had no significant influence on dietary selection of the grazing sheep. The lack of dietary selection was reflected in the small and non-significant differences in the green herbage proportion of total herbage on offer, which was expected to decrease with increasing grazing intensity and decreasing herbage availability respectively. It was also demonstrated that only minimal differences in herbage quality within the grassland sward occurred in 2005. Especially, the vertical quality structure was rather homogenous, constraining the sheep in their ability to select a diet higher in dietary quality than the average herbage on offer.

Acknowledgements

This study is part of the Research Unit MAGIM (Matter fluxes in grasslands of Inner Mongolia as influenced by stocking rate), which was funded by the Deutsche Forschungsgemeinschaft (FG 536). We would like to thank the Institute of Botany (Chinese Academy of Sciences) and IMGERS for the opportunity to carry out this grazing experiment and the farmers and numerous field workers for their support and assistance in accomplishing the extensive field work. We are also indebted to Karin Makoben for laboratory assistance and to Dr. Ralf Loges for...
the nirs calibrations of feed quality variables at Kiel University.

References


Lancaster, R. J., 1949: The measurement of feed intake by grazing cattle and sheep. I. A method of calculating the digestibility of pasture based on the nitrogen content of faeces derived from the pasture. New Zealand Journal of Science and Technology 25, 31—58.


Menke, K. H.; Raab, L.; Salewski, A.; Steingass, H.; Fritz, D.; Schneider, W., 1979: The estimation of the digest-
ibility and metabolizable energy content of ruminant feedingstuffs from the gas production when they are incubated with rumen liquor in vitro. *Journal of Agricultural Science* **93**, 217—222.


