BRIEF COMMUNICATION: Walking distance and energy expenditure of beef cows grazing on hill country in winter

NP Martin[a], RE Hickson[a]*, I Draganova[b], D Horne[b], PR Kenyon[a] and ST Morris[a]

[a]*Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Private Bag 11222, Palmerston North 4442, New Zealand.* [b]*Institute of Agriculture and Environment, Massey University, Private Bag 11222, Palmerston North 4442, New Zealand.*

**Corresponding author.* Email: R.Hickson@massey.ac.nz

Keywords: energy; hill country; cows; walking

Introduction

Terrain, distribution of the herbage and its nutritive value determine the grazing strategy of beef cows (Henkin et al. 2012). Cows require more energy to walk uphill than on flat land (Brosh et al. 2006; Freer et al. 2007) and therefore prefer gentle terrain (Henkin et al. 2012) and paths that incur low costs in energy (Ganskopp et al. 2000). However, as herbage mass declines, the distribution of grazing becomes more uniform and all types of terrain may be explored (Henkin et al. 2012).

Beef breeding cows in New Zealand are frequently wintered on steep, exposed hill paddocks, but there is scarce information on where they move and the impact on energy requirements. This paper examines the movement of beef breeding cows grazing on hill country in winter, to identify preferences for gradients of terrain and to quantify the energy expenditure (EE) of the cows for walking.

Materials and methods

This experiment was conducted at Massey University's Tuapaka farm (15 km east of Palmerston North, New Zealand), with approval of the Massey University Animal Ethics Committee.

Experimental site and animals

Three similar, adjacent paddocks containing unrenovated hill country pasture, elevation range 100–360 m a.s.l., were used to conduct the experiment over two consecutive winters (2012 and 2013). Pasture covers were estimated fortnightly using a rising plate meter (Jenquip, New Zealand), with 100 readings per paddock. Pasture quality was assessed by collecting 20 pluck samples per paddock that were bulked into one sample for analysis. Quality analysis was done by the near infrared reflectance (NIR) spectroscopy method (Nutrition Laboratory, Massey University). During the first winter (2012), herbage was made up largely of mature stalky pasture of poor quality and low covers (Table 1). The second winter (2013) followed a severe drought and pastures had been grazed very low during the autumn. The pastures had higher quality and greater covers than the previous year, but the amount of herbage declined quickly and cows had to be shifted after six weeks.

Paddocks were stocked from 20th June to 22nd August

Table 1 Area, slope, stocking rate and pasture cover of paddocks and metabolisable energy (ME) content of pasture on offer in the experiment for 2012 and 2013. Paddocks were stocked with either Angus (AA), Angus x Friesian (AF), or Angus x Jersey (AJ) pregnant cows.

	Paddock 9	Paddock 10	Paddock 11	Overall
Area (ha)	12.75	8.75	8.04	29.6
Maximum Slope (°)	62	52	50	62
Proportion of area (%)				
Gentle (slope<17°)	45	32	39	40
Moderate (17°≤slope<35°)	47	55	52	51
Steep (slope≥35°)	8	13	9	10
Year 2012				
Cows				
Breed	AA	AJ	AF	
Stocking rate				
Cows/ha	2.67	2.63	2.61	2.64
kg LW/ha[1]	1409	1176	1325	1317
Pasture				
Cover at start (kg DM/ha)	1041	1164	973	1059
Cover at end (kg DM/ha)	975	1025	900	969
ME content (MJ/kg DM)				7.2
Year 2013				
Cows				
Breed	AA	AF	AJ	
Stocking rate				
Cows/ha	2.20	2.29	2.61	2.37
Kg LW/ha[1]	1200	1207	1229	1210
Pasture				
Cover at start (kg DM/ha)	1510	1341	1279	1398
Cover at end (kg DM/ha)	1105	968	897	1009
ME content (MJ/kg DM)				10.9

[1] Stocking rate expressed as kg of cow live weight per hectare on the first day in the paddock.

2012 and 17th June to 31st July 2013. Each herd contained 2008-born beef breeding cows that were either Angus (AA), Angus x Friesian (AF), or Angus x Jersey (AJ) (Table 1). All cows were pregnant, with planned start of calving on September 15th each year. Cows were weighed every 2 weeks.

Experimental period: cow movement and energy calculations

Ten cows of each breed were fitted with a neck -collar mounted with a Global Positioning System (GPS) unit for a 6-day experimental period: 16th–21st August in 2012 and 11th–16th July in 2013. The GPS units were custom-made using Trimble® Lassen modules (Draganova 2012) programmed to run continuously, logging position whenever a cow moved ≥4 m or every 1 minute if the cow did not move during that time. The standard deviation of points was 1.2m (range 0.0-15.2m). The GPS coordinates were converted to New Zealand map grid coordinates using ArcGIS 9 (ArcMap Version 9.3, USA) and a layer of GPS locations was generated. The collar of 1 AA cow malfunctioned in 2013 so 59 cow records were considered in this analysis. Of the 59 cow records, there were 51 individual cows, including 8 cows (n=2 AA, n=3 AF, n=3 AJ) that were measured in both years. For each 24-hour period, the positioning data was used to calculate the total distance walked, total distance walked on gentle (<17°), moderate (17°≤slope<35°) and steep (≥35°) terrain, and distance walked uphill.

Pasture covers and cow live weight were measured 8 (2012) or 10 (2013) days before, and the day after the GPS experimental period. Live weight on each day was calculated using linear interpolation between the two weights, and liveweight gain was calculated as average daily gain between the two weight records. Individual calving dates were used to estimate day of pregnancy for each cow assuming a 282 day gestation length. Conceptus weight was estimated for each day based on individual calf birth weight (Freer et al. 2007) and subtracted from live weight to give conceptus-free live weight and liveweight gain.

Energy expenditure was calculated based on theoretical requirements (Freer et al. 2007) and implied pasture consumption was calculated from total EE. For movement on uphill, EE (kJ/km/kg live weight) = $2.6\cos\theta + 28\sin\theta$, where θ is the slope of the ground. All movement within a slope category was assumed to be at the mid-point of the range in slope for that category.

Statistical analysis

Statistical analysis was conducted using SAS (v9.3, SAS Institute Inc., Cary, NC, USA). Mixed models were used to analyse EE. The models included the fixed effects of breed, year and day within year and the random effect of cow to allow for repeated measures. Paddock was not fitted because it was confounded with breed. Live weight and liveweight gain were analysed using a mixed model that included the fixed effects of breed and year.

Results and discussion

Cows walked a greater distance on gentle and moderate slopes in 2013 than in 2012 (P<0.05; Table 2), but there was no difference between years in the distance walked on steep slopes. Total distance walked per day was 3.36±0.05 and 2.73±0.04 km for 2013 and 2012 respectively, which was further than the mean distance to the milking shed for large dairy herds (Tucker et al. 2005). More than half of the distance walked was on a slope less than 17°, and only around 10% of the total distance was walked uphill. These findings are in agreement with previous studies (Brosh et al. 2006) and highlight that cattle choose trails that traverse lesser grades than one would expect from examination of the paddocks (Ganskopp et al. 2000).

Cows largely avoided steep slopes; approximately 5% of their movements were in this area. Eighteen percent of distance travelled on steep slopes was uphill, which represents 1% of total distance travelled per day (data not shown). Within moderate slopes, 13% of movement was uphill, compared with 6% of movement on gentle slopes. Cows had greater EE for walking in 2013 compared with 2012 (P<0.05, Table 2). Walking uphill accounted for

Table 2 Least-squares means (± SEM) for distance walked, live weight, energy expenditure and implied pasture consumption of pregnant beef cows in winter on hill country.

	2012	2013	P value
Distance walked			
Total distance walked (km/d)	2.73 ± 0.04	3.36 ± 0.05	0.001
Distance walked uphill (km/d)	0.26 ± 0.01	0.29 ± 0.01	0.01
Distance walked (km/d) in slope class			
Gentle (slope<17°)	1.53 ± 0.04	1.80 ± 0.04	0.01
Moderate (17°≤slope<35°)	1.06 ± 0.03	1.41 ± 0.03	0.001
Steep (slope≥35°)	0.14 ± 0.01	0.16 ± 0.01	NS
Live weight			
Live weight (on day 1 of GPS period; kg)	518 ± 6	534 ± 6	NS
Conceptus-free live weight (kg)	473 ± 6	503 ± 7	0.05
Conceptus-free liveweight change (kg/d)	-1.32 ± 0.09	0.26 ± 0.09	0.001
Energy Expenditure for			
Maintenance excluding walking (MJ ME/d)	58.91 ± 0.26	52.91 ± 0.27	0.001
Walking			
All directions (MJ ME/d)	7.17 ± 0.13	8.43 ± 0.11	0.001
Uphill (MJ ME/d)	2.49 ± 0.08	2.88 ± 0.06	0.01
Maintenance including walking (MJ ME/d)	66.67 ± 0.33	61.34 ± 0.30	0.001
Pregnancy (MJ ME/d)	18.46 ± 0.37	10.36 ± 0.18	0.001
Total excluding liveweight change (MJ ME/d)	85.13 ± 0.44	71.71 ± 0.33	0.001
Liveweight change (MJ ME/d)	-39.86 ± 1.42	14.24 ± 1.19	0.001
Total including liveweight change (MJ ME/d)	45.27 ± 1.46	85.93 ± 1.31	0.001
Implied pasture consumption (kg DM/d)	6.28 ± 0.20	7.89 ± 0.12	0.001

around 34% of the EE for walking even though uphill walking was <10% of the total distance walked.

When EE for maintenance was compared, the effect of lower pasture quality on efficiency of energy use for maintenance (Freer et al. 2007) was apparent, in that there was greater EE in 2012 than 2013 despite lighter cows and shorter distance walked. Energy expenditure for walking accounted for 11% in 2012 and 14% in 2013 of EE for maintenance and 8.4% in 2012 and 11.8% in 2013 of total EE excluding liveweight gain. These values are consistent with a study by Brosh et al. (2006) in which the cost of all activities accounted for 5.8-11.4% of the daily EE.

Total EE including liveweight change in 2012 was approximately half of the total EE including liveweight change in 2013 ($P<0.05$, Table 2). This was a reflection of the large liveweight loss in 2012 compared with a small liveweight gain in 2013. Total energy on offer (kg DM/ha x MJ ME/kg DM) was approximately doubled from 2012 to 2013 (7625 versus 15238 MJ ME, respectively) so the differences in liveweight change are unsurprising. Liveweight change in this experiment was calculated over a short time frame, and may have been confounded by decreased gutfill as time spent in the paddock increased.

In conclusion, beef cows walked 2.73–3.36 km/d on hill country. They walked greater distances on gentle and moderate slopes, generally avoiding slopes over 35° and walking uphill. Energy expenditure for walking was 8.4–11.8% of the total EE excluding liveweight gain. This new knowledge is valuable in reinforcing the existing estimates of the maintenance energy requirements of beef cows on steep hill country. More research is needed to determine how much these values change in different seasons, paddocks and with different groups of cows.

Acknowledgements

This experiment was funded by Massey University and Beef + Lamb NZ. The technical assistance of Phil Brooks and Johno Brophy is gratefully acknowledged.

References

Brosh A, Henkin Z, Ungar ED, Dolev A, Orlov A, Yehuda Y, Aharoni Y. 2006. Energy cost of cows' grazing activity: Use of the heart rate method and the Global Positioning System for direct field estimation. Journal of Animal Science 84: 1951-1967.

Draganova I. 2012. Nutrient distribution and behaviour of livestock in an intensively managed dairy herd: a thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy. Massey University, Palmerston North, New Zealand.

Freer M, Dove H, Nolan JV. 2007. Nutrient requirements of domesticated ruminants. Collingwood, Australia: CSIRO Publishing. pp 270.

Ganskopp D, Cruz R, Johnson DE. 2000. Least effort pathways?: A GIS analysis of livestock trails in rugged terrain. Applied Animal Behaviour Science 68: 179-190.

Henkin Z, Ungar ED, Dolev A. 2012. Foraging behaviour of beef cattle in the hilly terrain of a Mediterranean grassland. Rangeland Journal 34: 163-172.

Tucker CB, Verkerk GA, Small BH, Tarbotton IS, Webster JR. 2005. Animal welfare in large dairy herds: a survey of current practices. Proceedings of the New Zealand Society of Animal Production 65: 127-131.