Short communication: Milk output in llamas (*Lama glama*) in relation to energy intake and water turnover measured by an isotope dilution technique

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ABSTRACT

Despite the fact that llamas have become increasingly popular as companion and farm animals in both Europe and North America, scientific knowledge on their nutrient requirements is scarce. Compared with other livestock species, relatively little is known especially about the nutrient and energy requirements for lactating llamas. Therefore, we aimed to measure milk output in llama dams using an isotope dilution technique and relate it to energy intakes at different stages of lactation. We also validated the dilution technique by measuring total water turnover (TWT) directly and comparing it with values estimated by the isotope dilution technique. Our study involved 5 lactating llama dams and their suckling young. Milk output and TWT were measured at 4 stages of lactation (wk 3, 10, 18, and 26 postpartum). The method involved the application of the stable hydrogen isotope deuterium (²H) to the lactating dam. Drinking water intake and TWT decreased significantly with lactation stage, whether estimated by the isotope dilution technique or calculated from drinking water and water ingested from feeds. In contrast, lactation stage had no effect on dry matter intake, metabolizable energy (ME) intake, or the milk water fraction (i.e., the ratio between milk water excreted and TWT). The ratios between TWT measured and TWT estimated (by isotope dilution) did not differ with lactation stage and were close to 100% in all measurement weeks, indicating that the D₂O dilution technique estimated TWT with high accuracy and only small variations. Calculating the required ME intakes for lactation from milk output data and gross energy content of milk revealed that, with increasing lactation stage, ME requirements per day for lactation decreased but remained constant per kilogram of milk output. Total measured ME intakes at different stages

of lactation were similar to calculated ME intakes from published recommendation models for llamas.

Key words: lactation, llama, energy expenditure, growing young

Short Communication

In the last 20 yr, llamas and alpacas, 2 domesticated New World camelids, have become increasingly popular as companion and farm animals in Australia, North America, and Europe (i.e., outside their natural distribution range). However, very little scientific information is available on feeding recommendations in general and energy expenditure during lactation in particular compared with other livestock species. The resources transferred from a lactating mother to its suckling young during the course of a lactation are energetically more costly than the entire prenatal costs for gestation (Cameron, 1998).

Therefore, the objective of our study was to measure milk output in llamas using an isotope dilution technique and relate it to energy intake during lactation, thus being able to give some recommendations on the energy requirements for lactating llamas based on measured data not currently available. Furthermore, we aimed to validate the dilution technique by directly measuring water turnover and comparing it with values estimated by the isotope dilution technique.

For our study, 5 female llamas (between 9 and 16 yr of age) and their suckling young (crias) were involved. All animals involved were bred in Germany and originated from the herd of the Experimental Station Relliehausen of Göttingen University. Animals were transferred 2 mo before parturition for acclimation and were kept at the research facilities of the Department of Animal Sciences, University of Göttingen, Germany, for a lactation period of 27 wk under controlled stable conditions. All dams were multiparous and gave birth to a single young in May or June 2009 (2 female and 3 male crias). During measurement weeks, each dam was kept with its cria individually in a room measuring 5.8 m × 3.2 m with permanent access to an outdoor pen, allowing animals to see their conspecifics. In the

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stable, the light schedule was kept constant (14 h light to 10 h dark). Dams were offered chopped hay from perennial ryegrass-dominated grassland for ad libitum intake and 1 kg of a commercial compound feed (HG 58 S, Raiffeisen-Agravis AG, Rosdorf, Germany) fed in 2 portions of 0.5 kg twice a day (0800 and 1700 h). To measure feed and water intakes individually for the dams, hay was offered in a hay rack positioned 1.5 m above ground to prevent crias from accessing it. During the milk output trials at wk 3, 10, 18 and 26 (see below), hay consumption was measured daily for 1 wk by weighing and reweighing the amounts of hay offered. Similarly, water was available ad libitum in buckets positioned 1.5 m above ground, and daily water consumption was determined during the milk output trial weeks by weighing and reweighing water buckets. Two hay samples were taken for each respective measurement week. All samples were milled with a 1-mm sieve in a cutting mill (after premilling with a 10-mm sieve; model SM1, Retsch, Haan, Germany). Chemical analyses were done according to VDLUFA (2007) for DM (method 3.1), ash (method 8.1), CP (method 4.1.2; Dumas procedure), and ether extract (method 5.1.1). Detergent fiber analyses (NDF and ADF) were done according to Van Soest and Robertson (1985), with NDF analyzed with amylase and both corrected for ash. The ME was estimated using prediction equations for ruminants (GfE, 2009), including values from Hohenheim gas test (Menke et al., 1979).

The average (SD) hay composition was (g/kg of DM unless otherwise stated) ash: 85 (3.0), CP: 83 (1.3), ether extract: 24 (0.7), ADF: 390 (4.3), NDF: 634 (5.1), and ME: 8.2 (0.1) MJ/kg of DM, and the average composition of the compound feed was (g/kg of DM unless otherwise stated) ash: 91, CP: 173, ether extract: 51, ADF: 203, NDF: 343, ME: 11.2 MJ/kg of DM. Mineral feed (HG MIN 13, Raiffeisen-Agravis AG, Minden Westfalen, Germany) was offered for ad libitum consumption.

Milk output was measured in 5 dams by using an isotope dilution technique (Coward et al., 1979; Haisma et al., 2003; Riek and Gerken, 2009). The method depends on measuring the transfer of deuterium (^2H)-labeled water from the mother to the young via milk. The 4 measurement time were at wk 3, 10, 18, and 26 postpartum and lasted 7 d each. Averages were calculated for the midpoint of each study period: 25, 73, 129, and 186 d postpartum. A detailed description of the technique and the calculations is given in Haisma et al. (2003) and Riek and Gerken (2009). In brief, a background blood sample was taken before the isotope administration from both dams and crias. The dams were then injected with a known amount of heavy water (D_2O , deuterium oxide; 99.90% purity, Euriso-

top GmbH, Saarbrücken, Germany), determined by the weight of the animals, recorded with a scale to the nearest 0.5 kg (model SR2000 MR, Tru-Test Ltd., Auckland, New Zealand). The body mass of dams and crias was also recorded at the end of each measurement period to determine BW changes. The mean ($\pm$ SD) amounts of D_2O administered to the dams per kilogram of BW were 0.201 ± 0.005 , 0.200 ± 0.003 , 0.198 ± 0.001 , and 0.199 ± 0.002 g, at wk 3, 10, 18, and 26 postpartum, respectively. The actual dose given was gravimetrically measured by weighing the syringes to the nearest 0.001 g before and after administration. During the trials within the respective measurement weeks, blood samples (5 mL) were taken from dams and crias every 1 to 2 d for determination of D_2O concentrations. Blood samples were centrifuged for plasma at $2,000 \times g$ for 15 min at room temperature and kept at -20°C until the determination of the ^2H concentration. Analyses were carried out at the Competence Center of Stable Isotopes (KOSI, Göttingen University, Göttingen, Germany). Isotope ratios of ^2H were measured using an on-line high temperature reduction technique in a helium carrier gas described previously (Gehre et al., 2004) and expressed relative to the Vienna standard mean ocean water (VSMOW), the international reference standard for D_2O . Individual samples were measured in triplicate and the averages calculated. Isotope equilibration concentration and fractional water turnover of the isotope was computed for each dam by extrapolating the regression of D_2O concentrations (C_t) on time: $C_t = C_0 \times e^{-k \times t}$, where C_0 is the equilibration concentration (intercept) for D_2O , k is the fractional water turnover (slope), and t is the time elapsed since tracer administration (Holleman et al., 1982). The dilution space for D_2O in the dam was calculated after Schoeller (1983) and Schoeller et al. (1986). The body mass of dams was constant over the measuring periods; therefore, no corrections for changing pool size were necessary. Total water turnover (**TWT**) of the dams estimated by the D_2O dilution technique (**TWT_d**) was then calculated as the product of TBW and k . Total water turnover was also calculated from conventional measurements (**TWT_m**) as the sum of drinking water intakes (measured by reweighing water buckets), the water ingested from feed stuff (i.e., hay and concentrate), metabolic water (i.e., water released from the oxidation of fat, protein, and carbohydrates), and milk water (see below). For the calculation of metabolic water, it was assumed that fat and protein from ingested feed stuff produce 1.07 and 0.42 g of water per gram of material oxidized (Van Es, 1969), respectively. To measure milk output of llama dams, and thus milk intake in crias, we fitted the measured D_2O concentrations in crias to the equation given in Haisma et al. (2003).

Daily ME intakes during the measurement periods were calculated from ingested daily amounts of hay, concentrate, and their respective analyzed ME contents. Daily ME required for lactation was calculated from milk output data and the respective gross energy content of milk. It was assumed that the efficiency of utilization of ME for lactation is 0.63 (NRC, 2007).

Milk samples from each dam for the corresponding measurement wk (i.e., wk 3, 10, 18, and 26 postpartum) were taken and analyzed for fat, protein, lactose, and fat-free DM determined by infrared absorption using an infrared spectrophotometer (Milkoscan FT 6500, Foss Electric, Hillerød, Denmark) adjusted for llama milk, as described in detail previously (Riek and Gerken, 2006). Gross energy in milk (**GE**) was estimated using the following equation (Perrin, 1958): GE (MJ/100 g) = $39.8 \times \text{fat} (\%) + 23.9 \times \text{protein} (\%) + 16.7 \times \text{lactose} (\%)$. The DM concentration of milk was calculated by adding the fat concentration of the milk to the fat-free DM. The output of GE was calculated by combining the milk output results with the respective milk GE concentration.

Statistical analyses were performed with the software package SAS (SAS Institute, 2008). A nonlinear regression procedure (PROC NLIN) in SAS was used to fit data to equations. A 2-way ANOVA was performed that include the effects of lactation stage and animal on various parameters using the general linear model procedure (PROC GLM), with animal as random effect

to account for repeated measures on the same animals and lactation as fixed effect: $Y_{ijk} = \mu + LS_i + A_j + e_{ijk}$, where Y_{ijk} = observation value; μ = overall mean; LS_i = fixed effect of the i th lactation stage (i : 1 = 3, 2 = 10, 3 = 18, 4 = 26 wk); A_j = random effect of the animal; e_{ijk} = random error. An integrated multiple range test (Student-Newman-Keuls) was used to detect differences between means with a 5% significance level.

Body weight, drinking water intake, TWT, and DMI for the 4 measurement periods during lactation (i.e., wk 3, 10, 18, and 26) are presented in Table 1. Body mass of dams did not differ between the different lactation stages. Similarly, no differences were detected for DMI whether expressed as total amount ingested per day or on a metabolic body size basis. In contrast, lactation stage did affect ($P < 0.001$) drinking water intake and TWT, whether estimated by the D₂O dilution technique or by calculation from ingested drinking water and water ingested from feeds (see Material and Methods for details). In both cases, water turnover decreased significantly with increasing lactation stage. The ratios between TWT_d and TWT_m did not differ with lactation stage and were close to 100% in all measurement weeks, indicating that the D₂O dilution technique estimated TWT with high accuracy and only small variation (Figure 1). Similar results on TWT have been reported for sheep and goats (Al-Ramamneh et al., 2010). Although water excreted via milk decreased with lactation ($P < 0.001$), the milk-water fraction did not change, indicat-

Table 1. Summary of drinking water intakes, DMI, total body water (TBW), total water turnover (TWT), and the accuracy of measuring TWT by an isotope dilution technique (TWT_d) compared with the conventional measurement of TWT (TWT_m) in llamas (*Lama glama*) at different stages of lactation (values are means $\pm$ SE; n = 5)

Parameter	Lactation stage (wk)				P-value	
	3	10	18	26	Age	Animal
BW (kg)	140.8 $\pm$ 10.2	139.2 $\pm$ 9.0	137.0 $\pm$ 7.7	137.6 $\pm$ 7.0	NS	<0.001
Water drunk ¹ (L/d)	8.75 $\pm$ 0.71 ^a	7.89 $\pm$ 0.60 ^b	7.34.0 $\pm$ 0.60 ^b	5.60 $\pm$ 0.55 ^c	<0.001	<0.001
Water drunk ¹ [mL/(kg ^{0.75} ·d)]	216 $\pm$ 18 ^a	196 $\pm$ 13 ^b	184 $\pm$ 14 ^b	141 $\pm$ 13 ^c	<0.001	NS
DMI (kg/d)	2.90 $\pm$ 0.30	3.03 $\pm$ 0.32	2.74 $\pm$ 0.21	2.71 $\pm$ 0.26	NS	<0.01
DMI [g/(kg ^{0.75} ·d)]	71 $\pm$ 5	75 $\pm$ 7	68 $\pm$ 3	68 $\pm$ 5	NS	NS
Water drunk/DMI [L/(kg·d)]	3.15 $\pm$ 0.41 ^a	2.66 $\pm$ 0.27 ^b	2.71 $\pm$ 0.20 ^b	2.15 $\pm$ 0.29 ^c	<0.001	NS
Milk-water output ² (L/d)	2.52 $\pm$ 0.40 ^a	2.49 $\pm$ 0.26 ^a	1.67 $\pm$ 0.24 ^b	1.46 $\pm$ 0.21 ^b	<0.001	<0.01
TBW (kg)	91.6 $\pm$ 6.5	96.8 $\pm$ 4.1	97.3 $\pm$ 5.3	93.9 $\pm$ 5.9	NS	<0.001
TBW (% of BW)	65.3 $\pm$ 2.1	70.1 $\pm$ 2.7	71.2 $\pm$ 2.7	69.1 $\pm$ 1.2	NS	NS
TWT _d ³ (L/d)	11.8 $\pm$ 0.9 ^a	10.8 $\pm$ 0.7 ^b	9.6 $\pm$ 0.8 ^c	7.6 $\pm$ 0.7 ^d	<0.001	<0.001
TWT _d ³ [mL/(kg ^{0.75} ·d)]	289 $\pm$ 17 ^a	267 $\pm$ 13 ^a	241 $\pm$ 16 ^b	191 $\pm$ 15 ^c	<0.001	<0.05
TWT _m ⁴ (L/d)	11.8 $\pm$ 0.9 ^a	10.7 $\pm$ 0.7 ^b	9.5 $\pm$ 0.7 ^c	7.7 $\pm$ 0.8 ^d	<0.001	<0.001
Milk-water fraction ⁵ (%)	21.3 $\pm$ 2.7	21.7 $\pm$ 2.0	18.3 $\pm$ 2.1	19.4 $\pm$ 2.4	NS	<0.001
TWT _m /TWT _d (%)	99.9 $\pm$ 0.5	99.5 $\pm$ 1.5	98.7 $\pm$ 1.3	100.2 $\pm$ 1.2	NS	<0.05

^{a-c}Means within a row with different superscripts differ ($P < 0.05$).

¹Measured by reweighing water buckets.

²Measured by an isotope dilution technique (see text for details).

³TWT measured by an isotope dilution technique (including drinking water, preformed water from feed, metabolic water, and milk water).

⁴TWT calculated by the sum of drinking water, measured by reweighing water buckets, preformed water from feed, metabolic water (calculated from feed composition data), and milk water.

⁵Relationship between milk-water output and TWT.

Table 2. Summary of ME intakes, milk output, and gross energy (GE) content (means $\pm$ SE; $n = 5$) of milk in llamas (*Lama glama*) at different stages of lactation

Parameter	Lactation stage (wk)				P-value	
	3	10	18	26	Age	Animal
ME intake ¹ (MJ/d)	26.3 $\pm$ 2.4	27.5 $\pm$ 2.6	25.1 $\pm$ 1.7	24.8 $\pm$ 2.2	NS	<0.01
ME intake ¹ [kJ/(kg ^{0.75} ·d)]	643 $\pm$ 38	678 $\pm$ 55	625 $\pm$ 23	621 $\pm$ 38	NS	<0.01
ME _{lac} ² (MJ/d)	18.5 $\pm$ 2.4 ^a	15.1 $\pm$ 1.7 ^b	12.2 $\pm$ 1.8 ^c	10.2 $\pm$ 1.3 ^c	<0.001	<0.001
ME _{lac} ² [MJ/(kg of milk·d)]	6.9 $\pm$ 0.4	6.1 $\pm$ 0.2	6.7 $\pm$ 0.3	6.5 $\pm$ 0.2	NS	NS
Milk output ³ (kg/d)	2.74 $\pm$ 0.73 ^a	2.49 $\pm$ 0.26 ^a	1.81 $\pm$ 0.26 ^b	1.58 $\pm$ 0.22 ^b	<0.001	<0.001
Milk output ³ [kJ/(kg ^{0.75} ·d)]	66 $\pm$ 8 ^a	61 $\pm$ 5 ^a	45 $\pm$ 5 ^b	39 $\pm$ 4 ^b	<0.001	<0.001
GE in milk (MJ/kg)	4.34 $\pm$ 0.24 ^a	3.82 $\pm$ 0.11 ^b	4.24 $\pm$ 0.17 ^{ab}	4.10 $\pm$ 0.01 ^{ab}	<0.05	NS

^{a-c}Means within a row with different superscripts differ ($P < 0.05$).

¹Sum of ME intakes from hay (8.2 MJ of ME/kg of DM) and concentrate (11.2 MJ of ME/kg of DM).

²ME for lactation; calculated assuming an efficiency of utilization of ME for lactation of 0.63 (NRC, 2007).

³Measured by an isotope dilution technique (see text for details).

ing a constant relationship between milk-water secretion and TWT during lactation. Total body water did not change with lactation stage, whether expressed in kilograms or as a percentage of BW.

Metabolizable energy intakes, milk output, and GE in milk for the 4 measurement periods during lactation are presented in Table 2. Although milk output decreased ($P < 0.001$) with lactation stage, the GE content of milk remained relatively stable during the

course of lactation, except in wk 3 and 10, when the GE content in milk differed ($P < 0.001$). Similar to DMI, ME intakes did not differ between different lactation stages, whether expressed as total amount ingested per day or on a metabolic body size basis (Table 2). However, calculating the required ME intakes for lactation from milk output data and GE content of milk showed that with increasing lactation stage, ME requirements per day for lactation decreased ($P < 0.001$) but remained constant per kilogram of milk output (Table 2), which is in agreement with data in sheep and goats (NRC, 2007). Furthermore, our results on milk output are comparable to those of earlier studies at similar stages of lactation and representative of the nutrient demands of suckling llamas (Riek et al., 2007).

In our study, lactating llamas ingested on average 643, 678, 652, and 621 kJ of ME/(kg^{0.75}·d; Table 2) at wk 3, 10, 18, and 26 postpartum, respectively. Calculating ME intakes for the same animals from recently published recommendations for energy requirements in llamas (NRC, 2007; Van Saun, 2009) resulted in slightly different values (i.e., 708, 685, 621, and 598 kJ of ME/(kg^{0.75}·d) at wk 3, 10, 18, and 26 postpartum, respectively). Although these recommendations for energy requirements in lactating llamas are based on extrapolations from sheep and goat data, comparison to our measured data indicates that they are largely accurate. However, our more detailed and measured, rather than extrapolated, data from sheep and goats on ME intakes in lactating llamas could serve as a basis for further recommendations for energy requirements in New World camelids.

Figure 1. Relationship between measured (calculated as the sum of measured drinking water intakes, water ingested from feed stuff, metabolic water, and milk water) and estimated (by the D₂O dilution technique) total water turnover in llama dams during lactation ($n = 20$). The straight line depicts the 100% line; that is, total water turnover estimated by D₂O = total water turnover measured.

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REFERENCES

- Al-Ramamneh, D., A. Riek, and M. Gerken. 2010. Deuterium oxide dilution accurately predicts water intake in sheep and goats. *Animal* 4:1606–1612.
- Cameron, E. Z. 1998. Is suckling behaviour a useful predictor of milk intake? A review. *Anim. Behav.* 56:521–532.
- Coward, W. A., M. B. Sawyer, R. G. Whitehead, A. M. Prentice, and J. Evans. 1979. New method for measuring milk intakes in breast-fed babies. *Lancet* 2:13–14.
- Gehre, M., H. Geilmann, J. Richter, R. A. Werner, and W. A. Brand. 2004. Continuous flow $^2\text{H}/^1\text{H}$ and $^{18}\text{O}/^{16}\text{O}$ analysis of water samples with dual inlet precision. *Rapid Commun. Mass Spectrom.* 18:2650–2660.
- GfE (Gesellschaft für Ernährungsphysiologie). 2009. New equations for predicting metabolisable energy of compound feeds for cattle. *Proc. Soc. Nutr. Physiol.* 18:143–146.
- Haisma, H., W. A. Coward, E. Albernaz, G. H. Visser, J. C. K. Wells, A. Wright, and C. G. Victoria. 2003. Breast milk and energy intake in exclusively, predominantly, and partially breast-fed infants. *Eur. J. Clin. Nutr.* 57:1633–1642.
- Holleman, D. F., R. G. White, and J. R. Luick. 1982. Application of the isotopic water method for measuring total body water, body composition and body water turnover. Pages 9–32 in *Use of Tritiated Water in Studies of Production and Adaptation in Ruminants*. International Atomic Energy Agency, Nairobi, Kenya.
- Menke, K. H., L. Raab, A. Salewski, H. Steingass, D. Fritz, and W. Schneider. 1979. The estimation of the digestibility and metabolizable energy content of ruminant feedingstuffs from the gas production when they are incubated with rumen liquor in vitro. *J. Agric. Sci.* 93:217–222.
- National Research Council. 2007. *The Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids and New World Camelids*. Natl. Acad. Press, Washington, DC.
- Perrin, D. R. 1958. The calorific value of milk of different species. *J. Dairy Res.* 25:215–220.
- Riek, A., and M. Gerken. 2006. Changes in llama (*Lama glama*) milk composition during lactation. *J. Dairy Sci.* 89:3484–3493.
- Riek, A., and M. Gerken. 2009. Milk intake studies in llamas (*Lama glama*) using the “dose-to-the-mother” technique. *Small Rumin. Res.* 82:105–111.
- Riek, A., M. Gerken, and E. Moors. 2007. Measurement of milk intake in suckling llamas (*Lama glama*) using deuterium oxide dilution. *J. Dairy Sci.* 90:867–875.
- SAS Institute. 2008. *SAS User’s Guide*. Release 9.02. SAS Institute Inc., Cary, NC.
- Schoeller, D. A. 1983. Energy-expenditure from doubly labeled water—Some fundamental considerations in humans. *Am. J. Clin. Nutr.* 38:999–1005.
- Schoeller, D. A., E. Ravussin, Y. Schutz, K. J. Acheson, P. Baertschi, and E. Jequier. 1986. Energy-expenditure from doubly labeled water—Validation in humans and proposed calculation. *Am. J. Physiol.* 250:R823–R830.
- Van Es, A. J. H. 1969. Report to the subcommittee on constants and factors: Constants and factors regarding metabolic water. Pages 513–514 in *Energy Metabolism of Farm Animals*. K. L. Blaxter, J. Kielanowski, and G. Thorbek, ed. Oriel Press, Newcastle upon Tyne, UK.
- Van Soest, R. J. 2009. Nutritional requirements and assessing nutritional status in camelids. *Vet. Clin. North Am. Food Anim. Pract.* 25:265–279.
- Van Soest, P. J., and J. B. Robertson. 1985. *Analysis of Forages and Fibrous Foods: A Laboratory Manual for Animal Science*. Dept. Anim. Sci., Cornell Univ., Ithaca, NY.
- VDLUFA. 2007. *Verband Deutscher Landwirtschaftlicher Untersuchungs- und Forschungsanstalten. Handbuch der Landwirtschaftlichen Versuchs- und Untersuchungsmethodik (VDLUFA-Methodenbuch)*, Bd. III. Die Chemische Untersuchung von Futtermitteln. VDLUFA-Verlag, Darmstadt, Germany.