Effects of Level of Energy Intake and Energy Demand on Growth Hormone, Insulin, and Metabolites in Targhee and Suffolk Ewes

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ABSTRACT: Yearling ewes (n = 32) were used in a 2 × 2 × 2 factorial experiment to determine effects of breed (Targhee vs Suffolk), energy intake (1 × vs 3 × NEm requirements, and physiological status (nonpregnant, nonlactating vs lactating) on serum GH, insulin, NEFA, glucose, and blood urea nitrogen (BUN) concentrations. Blood collections were made in two periods that began 21 and 32 d after ewes lambed. Lactating ewes had more GH peaks (P < .10), higher (P < .01) mean GH concentration, and greater (P < .01) area under the GH curve (AUC) than nonlactating ewes. The AUC was greater (P < .01) in ewes fed 1 × NEm than in ewes fed 3 × NEm. Energy intake had no effect on serum GH before feeding (P > .23) when evaluated within physiological statuses. After feeding, GH concentrations were greater (P < .10) for ewes fed 1 × NEm than for those fed 3 × NEm. Insulin and glucose did not differ (P > .23) between energy intake levels. Insulin and glucose were greater (P < .001) in nonlactating than in lactating ewes when evaluated within breed. Lactating and Targhee ewes fed 1 × NEm had greater (P < .001) NEFA concentration than nonlactating and Targhee ewes fed 3 × NEm, respectively. Ewes fed 3 × NEm and Targhee ewes had greater (P < .005) BUN concentrations than ewes fed 1 × NEm and Suffolk ewes, respectively. Physiological status seems to play a more important role in the regulation of GH than does energy intake. Higher BUN concentrations in Targhee than in Suffolk ewes demonstrates one metabolic event that distinguishes a breed’s adaptation to the environment in which it originated.

Key Words: Somatotropin, Metabolites, Glucose, Fatty Acids

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Introduction

Energy requirements of postpartum ewes increase to support lactation. Energy use is orchestrated by many endocrine factors, including GH. Johnson et al. (1985) reported that GH stimulated mammary parenchymal growth in ewes. Hart et al. (1978) attributed the effect of GH to a lipolytic action that mobilized body energy reserves to increase production of milk precursors. Head et al. (1993) reported that number of GH peaks, peak frequency, peak height, and concentration were greater in lactating than in nonlactating ewes. However, photoperiod, physiological stage, and intake were confounded in the study of Head et al. (1993). Hoefler and Hallford (1987) reported that in ewes nursing lambs the concentration of GH during the first 30 d of lactation was almost twice that of ewes whose lambs were weaned 2 d postpartum. In other physiological models, nutrient restriction in adult ovariectomized ewes resulted in increased serum GH concentration (Thomas et al., 1990; Kile et al., 1991). Previous data suggest that the extreme nutrient demands associated with lactation exert an influence over GH similar to that of the signals related to nutrient restriction. However, influences of breed type, physiological status, and level of energy intake have not been evaluated in one study. In addition, metabolic indices such as blood urea nitrogen (BUN), glucose, and serum fatty acids have not been included in the evaluation of GH given different breeds, physiological states, and energy intakes. The objective of this study was to evaluate BW, GH, insulin, glucose, NEFA, and BUN concentrations in two breeds (Targhee, a range wool breed; Suffolk, a farm flock meat breed) of lactating and nonlactating ewes consuming two levels of dietary energy.

The authors appreciate the technical support of E. Vadnais, J. Hopkins, K. Jensen, W. Gardner, D. Swanson, the National Hormone and Pituitary Program, the National Institute of Health, and A. Parlow for assay materials.

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Received July 10, 1998.
Accepted April 23, 1999.

1The authors appreciate the technical support of E. Vadnais, J. Hopkins, K. Jensen, W. Gardner, D. Swanson, the National Hormone and Pituitary Program, the National Institute of Health, and A. Parlow for assay materials.

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Table 1. Feedstuffs and diet composition (based on values of NRC, 1985)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>% as Fed</th>
<th>% CP&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Meal/kg&lt;sup&gt;ab&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>30.0</td>
<td>13.5</td>
<td>2.12</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>65.0</td>
<td>17.0</td>
<td>1.17</td>
</tr>
<tr>
<td>Vitamin and mineral premix&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.0</td>
<td>.0</td>
<td>.0</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>15.10</td>
<td>1.40</td>
</tr>
</tbody>
</table>

<sup>a</sup>DM basis.
<sup>b</sup>NRC (1985) NE<sub>m</sub> intake for maintenance 70 kg ewe = 1.35 Mcal/kg.
<sup>c</sup>Percentage composition on as-fed basis: salt, .14; monocalcium, .21%; phosphate, .02; magnesium oxide, .09; selenium (.006%), .05; zinc sulfate, .02, manganese sulfate, .01, vitamin A (8,000 IU) and D (800 IU) premix, .05; Vitamin E premix (40,000 IU), .08.

**Materials and Methods**

**Studies**

Yearling ewes (n = 32) were used to determine effects of breed (Targhee vs Suffolk), energy intake (1 × vs 3 × NE<sub>m</sub> requirements), and physiological status (nonpregnant, nonlactating vs peak lactation) on GH, insulin, NEFA, glucose, and BUN concentrations. Treatment combinations (n = 4) within breed were as follows: 1) lactating, 1× NE<sub>m</sub>; 2) lactating, 3× NE<sub>m</sub>; 3) nonpregnant, nonlactating, 1× NE<sub>m</sub>; and 4) nonpregnant, nonlactating 3× NE<sub>m</sub>. Two periods were used in which energy intake (1× or 3× NE<sub>m</sub>) was crossed over ewes (crossover design; Federer, 1967). Individual energy intake was calculated as 56 × BW<sup>0.75</sup> = kilocalories per day for the 1× NE<sub>m</sub> treatment and three times this level for the 3× NE<sub>m</sub> treatment (NRC, 1985).

The study was conducted in May and June, with Periods 1 and 2 beginning 21 and 32 d (SE = 4) after the pregnant ewes lambed, respectively. Before sampling in each period, ewes were penned individually (lactating, nonlactating vs peak lactation) on GH, insulin, NEFA, glucose, and BUN concentrations. Treatment diet. Ewes were fed a pelleted diet of barley, alfalfa, salt, minerals, and vitamins (Table 1) at 0800 and 1600 daily. A 30% concentrate diet was used to ensure that all ewes would consume the appropriate amount of feed when necessary to meet 3× NE<sub>m</sub>. Ewes were fed in elevated feeders to minimize consumption of the diet by lambs. Ewes and lambs had ad libitum access to water. To ensure maximum energy demand on lactating ewes from suckling, no supplemental feed was offered to lambs.

Each ewe was fitted with indwelling jugular catheters on d 7 of each period. Catheters were maintained patent using heparinized saline (25 IU/mL). Sham blood collections were performed on d 8 of each period at 15-min intervals for 2 h to condition ewes to the blood collection protocol.

Blood collections for serum GH were made on d 9 of each period. Blood samples were collected at 15-min intervals starting 2 h before feeding (0600) and continuing for 2 h after feeding (0945; 16 samples/ewe).

On d 10, vacuum tubes were used to collect blood for BUN, glucose, insulin, and NEFA determinations. Blood samples were collected hourly for 4 h starting at 0600 after an overnight shrink and before ewes were fed. Samples were collected into heparinized tubes.

All blood samples were centrifuged at 1,100 × g for 15 min at 4°C. Serum for GH was harvested and stored at −20°C. Concentrations of GH and insulin were determined with a double antibody RIA described by Fitzgerald and Stellflug (1991) and Sanson and Hallford (1984), respectively. Growth hormone concentrations were determined in seven assays with intra- and interassay CV of 5.6 and 10.4%, respectively. Growth hormone source used for iodination and standards were NIDDK oGH-I-4 and LER 1774, respectively. Variables of GH concentration profiles included mean basal concentration, pulse frequency, and pulse amplitude. These variables were generated with cluster analysis procedures (Veldhuis and Johnson, 1986). Insulin concentrations were quantified in a single assay having a CV of 11%.

Blood urea nitrogen concentrations were determined by spotting a 10-µL aliquot of sample onto a BUN Ekta-chem DT slide (Johnson & Johnson, Clinical Diagnostic Division, Rochester, NY). Slides were read on a Kodak DT-60 (Johnson & Johnson, Clinical Diagnostic Division). Nonesterified fatty acid concentrations were determined using a NEFA-C Kit from Wako (Wako Chemicals USA, VA). Glucose concentrations were determined using the Sigma procedure kit #510 (Sigma Chemical Co., St. Louis, MO). Sample duplicate CV for BUN, NEFA, and glucose were ≤ 2, 3, and 3%, respectively.

Sixteen-hour shrunk weights were taken at the beginning of Period 1, between Periods 1 and 2, and at the end of Period 2. Ewes and lambs were weighed on two consecutive days and averaged for starting, middle, and ending weights. Feed and water were removed at 1500 the day before weighing. Ewes and lambs were weighed at 0700 the following morning.

**Statistical Analysis**

Ewe was the experimental unit in the 2 × 2 factorial arrangement of treatments. Energy intake levels were crossed over ewes from Period 1 to 2. All models included fixed effects for breed, period, physiological status (energy demand), energy intake, and all possible interactions. Ewe BW, BW change, number of GH peaks, mean GH concentration, and area under the GH curve (AUC, trapezoidal summation method) were analyzed using the GLM procedure of SAS (1985). Additionally, the SAS (1985) repeated measures procedure was used to analyze GH concentrations for samples collected at 15-min intervals from 2 h before feeding through 2 h after feeding. The repeated measures procedure of SAS (1985) was also used to analyze BUN, insulin, glucose, and NEFA concentration in the four hourly samples collected on d 10 of each period. Least squares
Table 2. Body weight and DMI responses of ewes and lambs

<table>
<thead>
<tr>
<th>Item</th>
<th>Physiological status</th>
<th>Energy intake</th>
<th>Breed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nonlactating</td>
<td>Lactatingb</td>
<td>1× NEm</td>
</tr>
<tr>
<td>Initial Ewe BW, kg</td>
<td>58.3</td>
<td>57.7</td>
<td>56.9</td>
</tr>
<tr>
<td>Ewe DMI, kg/d</td>
<td>1.49**</td>
<td>1.62</td>
<td>.80**</td>
</tr>
<tr>
<td>Lamb BW, kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>9.1</td>
<td>10.3</td>
<td>11.0**</td>
</tr>
<tr>
<td>Change</td>
<td>4.1*</td>
<td>5.7</td>
<td>5.6†</td>
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<thead>
<tr>
<th>Item</th>
<th>Physiological status</th>
<th>Energy intake</th>
<th>Breed</th>
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<tbody>
<tr>
<td></td>
<td>Nonlactating</td>
<td>Lactatingb</td>
<td>1× NEm</td>
</tr>
<tr>
<td>Initial Ewe BW, kg</td>
<td>55.4</td>
<td>52.6</td>
<td>57.4**</td>
</tr>
<tr>
<td>Ewe DMI, kg/d</td>
<td>1.47**</td>
<td>1.60</td>
<td>.82**</td>
</tr>
<tr>
<td>Lamb BW, kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>16.0*</td>
<td>13.2</td>
<td>16.6**</td>
</tr>
<tr>
<td>Change</td>
<td>−.5*</td>
<td>1.4</td>
<td>.6</td>
</tr>
</tbody>
</table>

Physiological status × breed, physiological status × energy intake, and energy intake × breed interactions were not detected (P > .10).

bLactating ewes nursed a single lamb.

bNRC (1985).

dPeriod 1 began 21 d after lambing and continued for 10 d.

ePeriod 2 began 32 d after lambing and continued for 10 d.

fMeans within paired comparison differ.

†P < .10.

*P < .05.

**P < .01.

Period × energy intake and period × physiological status interactions were detected (P < .05) for ewe and lamb BW, lamb BW change, and DMI (Table 2). No period × breed interactions were detected (P > .20); however, for clarity breed effects are presented within period in Table 2. An energy intake × physiological status × breed interaction was detected for ewe BW change (P < .05). Lactating Suffolk (−9.0 kg) and Targhee (−8.1 kg) ewes fed 1× NEm lost more (P < .05) BW than nonlactating Suffolk (−5.0 kg) and Targhee (−3.7 kg) ewes fed 1× NEm and lactating Suffolk ewes (−4.2 kg) fed 3× NEm. The nonlactating and lactating Targhee ewes fed 3× NEm gained more (P < .05) BW (2.2 kg) than ewes on the previously mentioned treatments. Nonlactating Suffolk ewes fed 3× NEm gained the most (P < .05; 2.0 kg) BW.

In periods 1 and 2, DMI was 2.9 and 2.7 times greater (P < .01) for ewes receiving 3× NEm than for those receiving 1× NEm (Table 2). The slight reduction in DMI is attributed to ewes fed 3× NEm not always consuming the entire ration.

Single lambs suckling ewes fed 3× NEm gained more (P < .05) BW in Periods 1 and 2 than lambs suckling ewes fed 1× NEm (Table 2). Lambs nursing Suffolk ewes gained more (P < .10) BW in Period 1. No difference (P > .68) was detected in lamb BW change in Period 2.

Results

Body Weight and DMI

Period × energy intake and period × physiological status interactions were detected (P < .05) for ewe and lamb BW, lamb BW change, and DMI (Table 2). No period × breed interactions were detected (P > .20); however, for clarity breed effects are presented within period in Table 2. An energy intake × physiological status × breed interaction was detected for ewe BW change (P < .05). Lactating Suffolk (−9.0 kg) and Targhee (−8.1 kg) ewes fed 1× NEm lost more (P < .05) BW than nonlactating Suffolk (−5.0 kg) and Targhee (−3.7 kg) ewes fed 1× NEm and lactating Suffolk ewes (−4.2 kg) fed 3× NEm. The nonlactating and lactating Targhee ewes fed 3× NEm gained more (P < .05) BW (2.2 kg) than ewes on the previously mentioned treatments. Nonlactating Suffolk ewes fed 3× NEm gained the most (P < .05; 2.0 kg) BW.

In periods 1 and 2, DMI was 2.9 and 2.7 times greater (P < .01) for ewes receiving 3× NEm than for those receiving 1× NEm (Table 2). The slight reduction in DMI is attributed to ewes fed 3× NEm not always consuming the entire ration.

Single lambs suckling ewes fed 3× NEm gained more (P < .05) BW in Periods 1 and 2 than lambs suckling ewes fed 1× NEm (Table 2). Lambs nursing Suffolk ewes gained more (P < .10) BW in Period 1. No difference (P > .68) was detected in lamb BW change in Period 2.
Nonlactating Suffolk ewes fed 3× NE\textsubscript{m} gained the most (P < .05) BW, followed by nonlactating Targhee ewes fed 3× NE\textsubscript{m}, which gained more (P < .05) BW during the study than ewes assigned to any of the other treatments (Table 3). Lactating Suffolk and Targhee ewes fed 1× NE\textsubscript{m} lost more (P < .05) BW than ewes assigned to other treatment combinations. Nonlactating Targhee ewes fed 3× NE\textsubscript{m} lost less (P < .05) BW than nonlactating Suffolk ewes fed 3× NE\textsubscript{m}. In addition, lactating Targhee ewes fed 3× NE\textsubscript{m} gained BW, and lactating Suffolk ewes fed 3× NE\textsubscript{m} lost BW during the study (P = .19).

**Growth Hormone**

Mean concentration (P < .01), peaks per 4 h (P < .10), and AUC (P < .01) of GH profiles were greater in lactating than for nonlactating ewes (Table 3). Ewes fed 1× NE\textsubscript{m} had a greater (P < .01) AUC than ewes fed 3× NE\textsubscript{m}.

A physiological status × energy intake interaction (P = .07) was detected for the repeated measures analysis of GH concentration. No other interactions were detected (P > .10). When GH was analyzed before feeding, GH concentration was approximately 2.5 to 3 times greater (P < .001) for lactating ewes fed either 1× NE\textsubscript{m} or 3× NE\textsubscript{m} than for nonlactating ewes fed 1× NE\textsubscript{m} or 3× NE\textsubscript{m} (Figure 1). Growth hormone concentration did not differ (P > .22) between energy intake levels within physiological statuses before feeding. After feeding, GH concentrations were approximately three to four times greater (P < .001) for lactating ewes fed either 1× NE\textsubscript{m} or 3× NE\textsubscript{m} than for nonlactating ewes fed 1× NE\textsubscript{m} or 3× NE\textsubscript{m}. In addition, GH concentration tended (P = .10) to be greater for nonlactating ewes fed 1× NE\textsubscript{m} than for nonlactating ewes fed 3× NE\textsubscript{m}. After feeding, lactating

![Graph](https://via.placeholder.com/150)

Figure 1. Growth hormone concentrations from 120 min before feeding to 105 min after feeding. Pooled SEM for physiological status × energy intake and breed GH concentrations were .83 and .86 ng/mL, respectively. The P-values for physiological status × energy intake interaction and breed were .07 and .35, respectively. From −120 to 0 min, P-values for nonlactating 3× NE\textsubscript{m} vs nonlactating 1× NE\textsubscript{m}, nonlactating 3× NE\textsubscript{m} vs lactating 3× NE\textsubscript{m}, nonlactating 1× NE\textsubscript{m} vs lactating 1× NE\textsubscript{m}, and lactating 3× NE\textsubscript{m} vs lactating 1× NE\textsubscript{m} were .90, .001, .001, and .22, respectively. From 15 to 105 min, P-values for nonlactating 3× NE\textsubscript{m} vs nonlactating 1× NE\textsubscript{m}, nonlactating 3× NE\textsubscript{m} vs lactating 3× NE\textsubscript{m}, nonlactating 1× NE\textsubscript{m} vs lactating 1× NE\textsubscript{m}, and lactating 3× NE\textsubscript{m} vs lactating 1× NE\textsubscript{m} were .10, .001, .001, and .001, respectively. The P-values for breed effect (Suffolk vs Targhee) from −120 to 0 min and 15 to 115 min were .84 and .17, respectively.
Figure 2. Insulin concentration from 21 to 24 h postfeeding. Pooled SEM for energy intake and physiological status × breed were ± .019 and .028 ng/mL, respectively. The P-values for energy intake and physiological status × breed interaction were .23 and .08, respectively. The P-values for nonlactating Suffolk vs nonlactating Targhee, nonlactating Suffolk vs lactating Suffolk, nonlactating Targhee vs lactating Targhee, and lactating Suffolk vs lactating Targhee were .19, .001, .06, and .23, respectively.

ewes fed 1× NE\text{m} had four times greater GH concentration than lactating ewes fed 3× NE\text{m}.

Mean concentration, peaks per 4 h, and AUC of GH profiles did not differ (P > .32) between breeds (Table 3). In the repeated measures analysis, serum GH did not differ between breeds before (P = .35) or after (P = .17) feeding (Figure 1).

**Insulin**

With the exception of a physiological status × breed interaction (P = .08), no other interactions were detected (P > .20) for insulin. Insulin concentration did not differ (P = .23) between energy intake levels (Figure 2). However, insulin concentrations were consistently greater over the 4-h collection period in ewes fed 3× NE\text{m} than in those fed 1× NE\text{m}. Within physiological statuses, breeds did not differ (P > .19) in insulin concentrations. However, insulin concentrations were greater (P < .06) in nonlactating Suffolk and Targhee ewes than in lactating Suffolk and Targhee ewes.

**Glucose**

With the exception of a physiological status × breed interaction (P = .02), no other interactions were detected (P > .10) for glucose concentration. Glucose concentrations did not differ (P = .95) between ewes fed the 1× NE\text{m} and 3× NE\text{m} energy levels (Figure 3). However, ewes fed 3× NE\text{m} demonstrated a consistent decline in glucose concentration during the 4-h collection period, and ewes fed 1× NE\text{m} demonstrated a consistent increase.

Nonlactating Suffolk ewes had greater (P = .02) glucose concentration than nonlactating Targhee ewes (Figure 3). However, lactating Suffolk and Targhee ewes did not differ (P = .33) in glucose concentration. Glucose concentrations ranged from 35 (Targhee) to 56% (Suffolk) greater (P < .001) for nonlactating than for lactating ewes.

Glucose concentrations were greater (P = .001) in Period 1 than in Period 2 (data not shown). The reason for this difference is not clear. No interactions of period with any of the main effects were detected (P > .21).

**Nonesterified Fatty Acid**

Nonesterified fatty acids were determined to quantify internal body energy reserve mobilization (Johnson and Peters, 1993). Physiological status × period and breed × energy intake interactions were detected for NEFA
concentrations ($P < .05$; Figure 4). No other interactions were detected ($P > .20$). Concentrations of NEFA were greater ($P < .001$) for lactating ewes than for nonlactating ewes in both Periods 1 and 2.

Suffolk ewes fed $3 \times \text{NE}_m$ had greater ($P = .09$) NEFA concentration than Targhee ewes fed $3 \times \text{NE}_m$ (Figure 4). This was not the case for ewes fed $1 \times \text{NE}_m$. Although NEFA concentration did not differ ($P = .17$) between Suffolk ewes fed either $1 \times$ or $3 \times \text{NE}_m$, Targhee ewes fed $1 \times \text{NE}_m$ had greater ($P = .001$) NEFA concentrations than Targhee ewes fed $3 \times \text{NE}_m$.

**Blood Urea Nitrogen**

No interactions for BUN concentrations were detected ($P > .10$). Ewes fed $3 \times \text{NE}_m$ had greater ($P = .001$) BUN concentration than ewes fed $1 \times \text{NE}_m$ (Figure 5). Targhee ewes had greater ($P = .003$) BUN concentration than Suffolk ewes. No difference ($P = .70$) was detected between physiological statuses for BUN concentrations.

**Discussion**

Lactating ewes had greater measures of GH and NEFA concentrations, lower insulin and glucose concentrations (within breed comparisons), and, with the exception of Targhee ewes fed $3 \times \text{NE}_m$, lost more BW than nonlactating ewes. Physiological status did not influence BUN concentration.

The physiological status $\times$ energy intake interaction for the repeated measures analysis of GH shows a lactational influence on GH concentration before feeding with no impact of energy intake on GH prior to feeding. However, after feeding, GH concentration increased more rapidly in lactating and nonlactating ewes fed the $1 \times \text{NE}_m$ than in their $3 \times \text{NE}_m$ counterparts.

Head et al. (1993) reported that GH peak height and concentration were greater in ewes nursing twins than in ewes nursing a single lamb. Other researchers have also demonstrated that GH concentrations were greater in high- than in low-producing sheep (Hoefer and Hallford, 1987) and cattle (Hart et al., 1978). In addition, Head et al. (1996) reported that GH concentrations were greater in ewes selected for high ovulation rate than in randomly bred control ewes.

Although a physiological status $\times$ breed interaction was detected for insulin and glucose concentrations and a physiological status $\times$ period interaction was detected for NEFA concentration, lactating ewes consistently had lower insulin and glucose concentrations regardless of breed and greater NEFA concentrations regardless of period. These findings agree with research by Weekes (1986), who stated that level of insulin secretion is subject to homeorrhetic inhibition in catabolic states such as lactation. The interactions for both insulin and
Figure 4. NEFA concentration from 21 to 24 h postfeeding. Pooled SEM for energy intake × breed and physiological status × period NEFA concentrations were 46.9 and 45.3 µeq/L, respectively. The \( P \)-values for energy intake × breed and physiological status × period interactions were .05 and .01, respectively. The \( P \)-values for 3× NE\(_m\) Suffolk vs 3× NE\(_m\) Targhee, 3× NE\(_m\) Suffolk vs 1× NE\(_m\) Suffolk, 3× NE\(_m\) Targhee vs 1× NE\(_m\) Targhee, and 1× NE\(_m\) Suffolk vs 1× NE\(_m\) Targhee were .09, .17, .001, and .33, respectively. The \( P \)-values for nonlactating Period 1 vs nonlactating Period 2, nonlactating Period 1 vs lactating Period 2, nonlactating Period 2 vs lactating Period 2, and lactating Period 1 vs lactating Period 2 were .20, .001, .001 and .004, respectively.

Gow et al. (1981) reported that food intake and GH concentration are inversely related, suggesting that GH is involved in energy balance of ewes. Kile et al. (1991) found that reduced dietary energy in ewes resulted in approximately a 10-fold increase in serum GH. Other researchers have observed similar effects of nutrient status on GH concentrations (Foster et al., 1989; Thomas et al., 1990). Our results demonstrate that the influence of energy intake on GH concentration may be influenced by time of measurement relative to feeding.

Ewes fed 1× NE\(_m\) lost more BW, had greater GH concentrations after feeding and AUC, and greater BUN than ewes fed 3× NE\(_m\). In addition, NEFA concentration was greater in Targhee ewes fed 1× NE\(_m\) than in Targhee ewes fed 3× NE\(_m\), but it did not differ in Suffolk ewes. Number of GH peaks per 4 h, mean GH concentration, GH concentration before feeding, and insulin and glucose concentrations did not differ between energy intake levels.

Gow et al. (1981) reported that food intake and GH concentration are inversely related, suggesting that GH is involved in energy balance of ewes. Kile et al. (1991) found that reduced dietary energy in ewes resulted in approximately a 10-fold increase in serum GH. Other researchers have observed similar effects of nutrient status on GH concentrations (Foster et al., 1989; Thomas et al., 1990). Our results demonstrate that the influence of energy intake on GH concentration may be influenced by time of measurement relative to feeding.

It is possible that the increase in GH concentration after feeding for the 1× NE\(_m\) compared with the 3× NE\(_m\) treatment was the result of a lipolytic action of GH in mobilizing internal body energy reserves (Hart et al., 1978) to compensate for the lower energy intake. It is unclear why ewes fed 1× NE\(_m\) did not demonstrate an increase in GH concentration before feeding.

Bremmers et al. (1988) reported that insulin concentration in rams fed at 1.2× NE\(_m\) requirement for maintenance was greater than in those fed at .7× maintenance. We found no difference in insulin concentrations between energy intake levels. However, insulin concentrations were consistently greater over the 4-h collection period for 3× than for 1× NE\(_m\) treatments, which would tend to agree with the results of Bremmers et al. (1988).

Although energy intake did not influence glucose concentration, ewes fed 1× NE\(_m\) demonstrated a constant increase and ewes fed 3× NE\(_m\) demonstrated a decline in glucose concentration during the 4 h before feeding. The increase in glucose in the 4 h before feeding by the ewes on the 1× NE\(_m\) treatment may indicate an increase in gluconeogenesis in response to demand. However, Schmidt and Keith (1983) stated that glucose supply does not seem to be tightly controlled in relation to...
Figure 5. Blood urea nitrogen (BUN) concentrations from 21 to 24 h postfeeding. Pooled SEM for energy intake, physiological status, and breed BUN concentrations were .74, .71, and .72 mg/dL, respectively. The $P$-values for energy intake, physiological status, and breed were .001, .70, and .003, respectively.

In general, BW loss was greater in lactating Suffolk ewes and Suffolk ewes fed the low-energy diet than in their Targhee counterparts. However, Suffolks gained more BW when nonlactating and fed $3\times NE_m$ than did nonlactating Targhee ewes fed $3\times NE_m$. Glucose in nonlactating ewes and NEFA in ewes fed $3\times NE_m$ concentrations were lower in Targhees than in Suffolk ewes. Glucose in lactating ewes and NEFA in ewes fed $1\times NE_m$ concentrations did not differ between breeds when lactating. No differences in measurements of GH and insulin were detected between breeds. Targhee ewes had greater BUN concentrations than Suffolk ewes.

Head et al. (1993) reported that number of GH peaks, peak frequency, peak height, and concentration were greater in Targhee than Suffolk ewes. In our study, no differences ($P > .17$) were detected between Targhee and Suffolk ewes. The difference among these studies in the influence of breed on GH concentrations is not clear.

In general, urea transfer via the saliva to the rumen is directly related to the BUN concentration. This affects the concentration in the saliva (Somers, 1961b), where urea accounts for .6 to .7 of the total N content (Somers, 1961a). One possible explanation for the greater BUN, and thus greater amount of urea cycled to the rumen, in the Targhee breed is its development as a range breed, whereas the Suffolk was developed in a more nutrient-rich environment. Animals that recycle more N to the rumen may be better able to adapt to low-quality forages (Frisch and Vercoe, 1991).

Low BUN concentrations have been associated with selection for increased fleece weight (Clark, 1987; McCutcheon et al., 1987) and decreased fatness in sheep (Carter et al., 1986). Possibly, Suffolk sheep have a greater ability to match dietary amino acid profiles to requirements. However, in nutritionally stressed environments, this ability may become a liability in the absence of adequate dietary protein levels. This is supported in part by our findings on ewe BW change. In general, when Suffolks had low energy requirements (i.e., nonlactating) and were fed in excess of energy demands, they had better weight gain than Targhee ewes. However, when energy intake was low or energy demands high, Targhee ewes tended to gain more or lose less BW than Suffolk ewes. Although Ramsey et al. (1998) reported that ADG was greater for suckling Suffolk than for Targhee lambs, Rastogi et al. (1975) reported that the Targhee lambs had a greater ADG postweaning than Suffolk lambs when fed a 12.5% CP diet.
Implications

The endocrine milieu affects lactation through a variety of pathways. Growth hormone, insulin, glucose, nonesterified fatty acids, and blood urea nitrogen may be used to evaluate differences in energy intake, demand, and breed within a single study. Both high-energy demand and low-energy intake result in greater production of growth hormone. However, physiological status seems to play a more important role in regulating growth hormone than does energy intake. Higher blood urea nitrogen concentrations in Targhee than in Suffolk ewes demonstrates one metabolic event that distinguishes a breed’s adaptation to the environment in which it originated.

Literature Cited


