RELATIONSHIPS AMONG PROTEIN SUPPLEMENTATION, SELECTED BLOOD CONSTITUTENTS, AND PERFORMANCE OF GRAZING STEERS

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ABSTRACT

Beef steers grazing tobosagrass (Hilaria mutica [Buckl.] Benth.) range in western Texas were allocated to 3 groups (10 head/group) and fed either 0.00, 0.75, or 1.50 lb/hd/day of cottonseed meal each year of a 2-year study. Steer weights and samples of blood were collected at 21-day intervals beginning in April and ending in July to evaluate relationships among plane of nutrition, average daily gain (ADG), and selected blood components. Plasma was analyzed for glucose (GLU), non-esterified fatty acids (NEFA), thyroxine (T4), and triiodothyronine (T3). No consistent relationships were observed between supplement level and blood constituents. Serum GLU, T3, and T4 generally declined through each season as forage quality declined but did not closely reflect changes in daily gain of steers (r=0.04, -0.05, -0.01, respectively). Environmental factors may have had a greater effect on daily gain than diet quality and, therefore, precluded the development of any useful relationships among blood components and ADG.

INTRODUCTION

Monitoring the nutritional status of free-grazing animals by present methods is expensive and time consuming for researchers and virtually impossible for producers. Estimates of fecal output and diet digestibility are required for estimating forage intake. If these methods can be replaced by more efficient means of arriving at nutritional status, both researchers and producers would benefit.

Different blood constituents have potential for use as indicators of nutrient intake and nutritional status of ruminants. Several blood constituents have been related to energy intake. Plasma non-esterified fatty acids (NEFA) are expected to increase as energy intake decreases and adipose tissue is mobilized (Bowden and Hironaka 1975). This relationship has been observed in white-tailed deer (**Odocoileus virginianus**) (Seal et al. 1978), heifers, and cows (**Bos taurus**) (Russel and Wright 1983, Bowden 1971).

Bowden and Hironaka (1975) observed elevated levels of glucose (GLU) as the body condition of non-pregnant, non-lactating Angus and Hereford beef cows improved. Combinations of GLU and growth hormone have been positively correlated with weight gain in cows (Hart et al. 1979).

In studies with white-tailed deer, triiodothyronine (T3) was strongly related to energy intake, increasing from 304 to 394 ng/dl when dietary energy was increased from a low to a moderate level (Seal et al. 1978). Baccari et al. (1983) developed correlations between weight gain and T3 in Holstein heifers (r=0.91) indicating the T3 may reflect changes in weight gain in cattle. Relationships between growth rate and thyroxine (T4) have been observed in weaned sheep (Rhind et al. 1984).

The objectives of this study were to describe the relationships among plane of nutrition (level of supplementation) and blood constituents, and to determine if these blood constituents could be used to predict weight change in grazing steers.

MATERIALS AND METHODS

Study Area

This study was conducted at the Texas Tech Experimental Ranch in Garza County, Texas. The area is dominated by a clay flat range site with gently sloping clay soils (fine, montmorillonitic, thermic Typic Chromusterts). Tobosagrass (**Hilaria mutica** [Buckl.] Benth.) is the dominant forage. Soil depressions contain alkali sacaton (**Sporobolus airoides** [Torr.] Torr.) and the more upland areas produce buffalograss (**Buchloe dactyloides** [Nutt.] Engelm.). Average yearly forage production, in excellent condition, is 1500 lb/ac (Richardson et al. 1965).

The climate is warm, temperate, and subtropical with dry winters. Average rainfall is 19 in. (Fig. 1) occurring mainly from May to October from convective thunderstorms. Drought is common. Average length of the growing season is 216 days. Mean elevation is 2600 ft (Richardson et al. 1965).

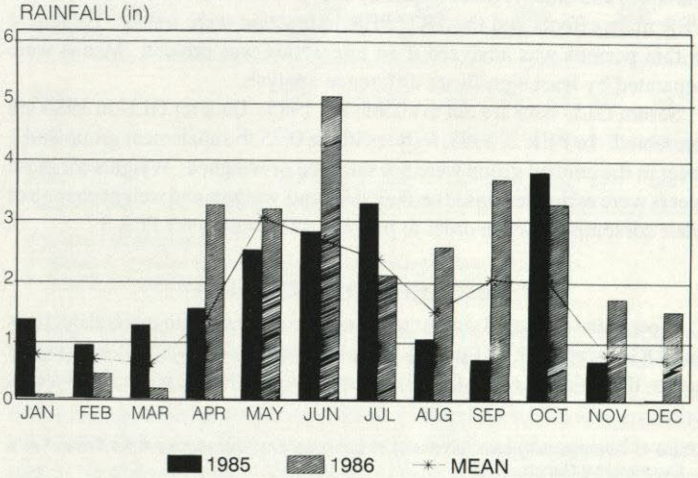

Figure: Monthly precipitation at the Texas Tech Experimental Ranch for 1985 and 1986 with the long term mean for Post, Texas.

Field Trials

Three herds, grazing 6-pasture grazing cells, were fed 1 of 3 rates of protein supplement (0.00, 0.75, or 1.50 lb/hd/day of cottonseed meal). Prorated amounts were fed 3 times per week in community troughs. Cell areas were 168, 225, and 235 ac. Stocking rate was based on forage production so that forage allowance/hd/day was similar in all three cells. Steers were rotated through the cells on 42-day cycles with length of stay in each pasture from 4-10 days.

Each cell was stocked in March each year with 27 to 57 crossbred steers (**Bos taurus x Bos indicus**) weighing 450-550 lbs. Steers were allowed to adjust to the grazing system and the 3-day feeding routine before trials began in April. In early to mid April, all steers were weighed after overnight fasting from food and water. This routine was repeated at 21 day intervals until July. In 1985, cattle were weighed on 23 April, 14 May (PER 1), 4 June (PER 2), 2 July (PER 3), and 23 July (PER 4). Steers were initially weighed on 7 April in 1986 and subsequently weighed on 28 April (PER 1), 19 May (PER 2), 9 June (PER 3), and 30 June (PER 4).

Ten steers from each treatment group were randomly selected for blood sampling before grazing started. Steers were selected from the middle weight class of the herd with a range of 50 lb. At 0700 h the evening before weighing, the 30 steers were sorted from the main herd to facilitate sampling and minimize excitement of the animals prior to sampling. Blood samples were taken and weights recorded between 0700 and 0800 hours the following morning. Two 10-ml blood samples were drawn from each steer via jugular puncture.

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Blood samples were immediately placed in ice and refrigerated overnight to allow the samples to coagulate. The following morning, samples were centrifuged at 3000 rpm for 10 min and the serum was extracted and frozen.

Laboratory Analyses

Serum T3 and T4 were determined by radioimmunoassay (T3 Set TKC31 and T4 Set TKT41, Diagnostic Products Corporation, Los Angeles, CA). Serum glucose concentration was analyzed colorimetrically using glucose oxidase (Glucose Set 510, Sigma Diagnostics, St. Louis, MO). Non-esterified fatty acids were determined by a colorimetric procedure (NEFA C Set 990-75401, Wako Pure Chemical Industries, Ltd., Osaka, Japan).

Statistical Analysis

Data were initially analyzed with treatment (TRT) and period (PER) as main effects and year as a repeated measure. Model components were TRT, PER, TRT*PER, YEAR, YEAR*TRT, YEAR*PER, and YEAR*TRT*PER. The YEAR*TRT interaction was significant for most variables and data were subsequently analyzed within year. Treatment and PER main effects and the TRT*PER interaction were tested. Treatment within periods was analyzed if an interaction was present. Means were separated by least significant difference analysis.

Serum GLU data are not available for 1985. Data for GLU in 1986 are presented. In PER 2, 1985, 6 steers in the 0.75 lb supplement group and 1 steer in the control group were not sampled or weighed. Weights for these steers were estimated based on their pervious weights and weight change of their contemporaries in order to provide ADG values for PER 3.

RESULTS AND DISCUSSION

Steer gains followed similar patterns in both years with marked declines in ADG during PER 3 (Table 1). Supplemented steers generally had greater gains than the control (CON) group except at PER 3 when CON steers outgained high supplement (HS) and low supplement (LS) steers ($P<0.05$). Period 3 coincided with the greatest amount of precipitation. Precipitation may have reduced grazing time or possibly increased cold stress. Traveling to and from feeding grounds through clay mud may have increased energy expenditure. Average daily gain for 1985 and 1986 for all groups was 1.3 lb and 1.4 lb, respectively.

Table 1. Average daily gain (lb/hd/day) of steers grazing tobosagrass at the Texas Tech Experimental Ranch.

1985								
Cottonseed meal (lb/hd/day)	4/23 to 5/14 Mean	SD	5/14 to 6/04 Mean	SD	6/04 to 7/02 Mean	SD	7/02 to 7/23 Mean	SD
0.00[1]	0.84[b]	0.84	1.71	0.42	1.03	0.48	0.86[b]	0.60
0.75	1.73[a]	0.75	1.84	0.81	0.65	0.51	0.87[b]	0.52
1.50	1.69[a]	0.68	2.08	0.41	0.62	0.69	1.79[a]	0.79

1986								
Cottonseed meal (lb/hd/day)	4/07 to 4/28 Mean	SD	4/28 to 5/19 Mean	SD	5/19 to 6/09 Mean	SD	6/09 to 6/30 Mean	SD
0.00	1.59	0.58	2.02	0.73	0.07[a]	0.53	1.66	0.35
0.75	2.00	0.43	1.88	0.57	-0.95[b]	0.53	2.15	0.66
1.50	1.87	0.40	2.80	0.42	-0.54[b]	0.56	2.17	0.54

[1] N=10 for all treatments.
[a] Means in a column followed by a different letter are different ($P<0.05$).

Relationships between supplement level and NEFA were not consistent between years (Table 2). Serum NEFA tended to be greater in the HS group in 1985 compared to the other groups ($P=0.11$) but no difference was observed between the HS and CON group in 1986. The HS and CON groups had greater NEFA than the LS group in 1986 ($P<0.01$). In both years NEFA increased ($P<0.05$) through the season as forage quality declined.

Table 2. Serum non-esterified fatty acid (mE/l) level in steers grazing tobosagrass at the Texas Tech Experimental Ranch.

1985								
Cottonseed meal (lb/hd/day)	5/14 Mean	SD	6/04 Mean	SD	7/02 Mean	SD	7/23 Mean	SD
0.00[1]	0.7	0.2	0.4	0.2	0.7	0.4	0.7	0.3
0.75	0.8	0.3	0.4	0.1	0.6	0.2	0.6	0.2
1.50	0.6	0.2	0.6	0.3	0.8	0.2	1.0	0.4
MEAN	0.7[x]	0.3	0.5[y]	0.2	0.7[x]	0.3	0.8[x]	0.3

1986										
Cottonseed meal (lb/hd/day)	4/28 Mean	SD	5/19 Mean	SD	6/09 Mean	SD	6/30 Mean	SD	MEAN Mean	SD
0.00	0.7	0.3	0.7	0.4	0.7	0.2	0.9	0.3	0.7[a]	0.3
0.75	0.5	0.2	0.3	0.1	0.6	0.1	0.7	0.3	0.5[b]	0.2
1.50	0.8	0.3	0.6	0.3	0.8	0.2	0.7	0.3	0.7[a]	0.3
MEAN	0.7[x]	0.3	0.5[y]	0.3	0.7[x]	0.2	0.7[x]	0.3		

[1] N=10 for all treatments.
[x,y] Means in a row followed by a different letter are different ($P<0.05$).
[a,b] Means in a column followed by a different letter are different ($P<0.05$).

No relationship was observed between NEFA and ADG in any period of the study (Table 3). Values for NEFA remained between 0.44 and 0.98 mE/l during both years and did not follow any consistent pattern. The

Table 3. Correlation coefficients for weight gain and blood constituents of steers grazing tobosagrass at the Texas Tech Experimental Ranch, 1985 and 1986.

	Average Daily Gain			
	PER 1[1]	PER 2	PER 3	PER 4
NEFA[2]	0.03	0.04	0.15	0.01
GLU[3]	0.25	0.21	-0.73*	0.43*
T3[4]	-0.05	0.07	-0.52*	0.38*
T4[5]	-0.03	0.20	0.41*	-0.43*

[1] PER=period, 21-day intervals beginning 23 April, 1985, and 7 April, 1986.
[2] NEFA=serum non-esterified fatty acids.
[3] GLU= serum glucose.
[4] T3=serum triiodothyronine.
[5] T4=serum thyroxine.
* Significant ($P<0.05$).

lack of relationship between NEFA, plane of nutrition, and growth may be partly due to excitation of the steers during collection which may have caused temporary elevated levels of NEFA (Bowden 1971). Because steers were gaining weight throughout each year (with the exception of the supplemented groups in PER 3, 1986) NEFA concentration would be expected to remain low (Russel and Wright 1983, Bowden and Hironaka 1975). Weight loss by the supplemented groups in PER 3 of 1986 was not reflected by elevated NEFA levels. This suggests that weight loss was a function of reduced gut fill rather than actual mobilization of body tissue. Although NEFA concentration has shown some potential for determining nutritional status of lactating cows with high energy demand (Russel and Wright 1983, Bowden 1971), current results indicate that NEFA level has little value in prediction of ADG in growing steers. A similar conclusion was drawn by Warren et al. (1982) with growing fawns. GLU declined seasonally for all treatments (P<0.01; Table 4). Serum GLU was positively correlated with ADG in PER 1 and PER 4, and negatively correlated in PER 3 when ADG was negative (Table 3).

Differences in GLU did not occur among treatments (Table 4). This response differs from Richardson (1984) where GLU concentration was

Table 4. Serum glucose levels (mg/dl) in steers grazing tobosagrass at the Texas Tech Experimental Ranch in 1986.

Cottonseed meal (lb/hd/day)	4/28		5/19		6/09		6/30	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0.00[1]	70.3	7.5	65.7	6.4	60.2	4.7	55.2	10.5
0.75	71.4	8.2	67.7	6.9	59.4	12.9	54.3	7.8
1.50	67.5	17.3	66.7	11.5	58.4	11.6	55.9	13.4
MEAN	69.7^{x}	11.6	66.7^{x}	8.3	59.3^{y}	10.0	55.1^{y}	10.5

[1] N=10 for all treatments.
^{x,y} Means in a row followed by a different letter are different (P<0.05).

Table 5. Serum triiodothyronine (ng/dl) levels in steers grazing tobosagrass at the Texas Tech Experimental Ranch.

1985								
Cottonseed meal (lb/hd/day)	5/14		6/04		7/02		7/23	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0.00[1]	93^{b}	63	112	43	63^{b}	34	58	24
0.75	84^{b}	35	74	34	88^{ab}	26	85	36
1.50	134^{a}	46	83	32	115^{a}	56	83	25
1986								
Cottonseed meal (lb/hd/day)	4/28		5/19		6/09		6/30	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0.00	93^{b}	25	128	30	118^{b}	24	88^{b}	10
0.75	123^{a}	25	144	20	150^{a}	38	131^{b}	35
1.50	126^{a}	21	146	22	150^{a}	15	162^{a}	22

[1] N=10 for all treatments.
^{a,b} Means in a column followed by a different letter are different (P<0.05).

Table 6. Serum thyroxine (ug/dl) levels in steers grazing tobosagrass at the Texas Tech Experimental Ranch.

1985										
Cottonseed meal (lb/hd/day)	5/14		6/04		7/02		7/23		MEAN	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0.00[1]	4.2	0.5	4.7	0.7	4.7	0.8	4.6	0.8	4.5^{b}	0.7
0.75	5.4	1.6	5.0	2.0	6.0	1.7	4.7	1.3	5.4^{a}	1.6
1.50	5.0	1.0	5.1	1.4	6.2	1.0	5.5	0.7	5.5^{a}	1.1
MEAN	4.9^{y}	1.2	4.9^{y}	1.2	5.6^{x}	1.4	4.9^{y}	1.0		
1986										
Cottonseed meal (lb/hd/day)	4/28		5/19		6/09		6/30			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
0.00	4.7^{b}	0.8	3.6^{b}	0.9	4.2^{a}	0.6	3.2^{a}	0.6		
0.75	4.7^{b}	0.8	1.8^{c}	0.6	2.4^{b}	0.8	1.3^{b}	0.5		
1.50	5.7^{a}	1.1	5.6^{a}	1.3	3.6^{a}	1.5	2.1^{b}	0.6		

[1] N=10 for all treatments.
^{a,b} Means in a column followed by a different letter are different (P<0.05).
^{a,y} Means in a row followed by a different letter are different (P<0.05).

elevated by reducing the protein-to-energy ratio in the diet. The negative response to reduced gain in PER 3 would indicate that GLU may be related to diet quality rather than total dietary intake since gains, and likely forage intake, dropped during this period with only a slight decline in forage quality and GLU. Richardson (1984) found elevated GLU with increased level of intake. In agreement with Richardson (1984), it appears that GLU is not useful in determining nutritional status of grazing animals.

Serum T3 levels tended to be greatest for the HS group during 1985. In 1986, HS and LS steers had higher T3 levels (P<0.05) during most of the grazing season (Table 5). The HS and LS groups had greater T4 levels (P<0.01) than the CON steers in 1985, HS and CON steers tended to have greater T4 in 1986 (Table 6). Correlations of thyroid hormones to ADG were also inconsistent with positive correlations observed between T3 and ADG at PER 4, and negative correlation at PER 3 (Table 3). Serum T4 was inversely related to ADG at PER 4, and positively related at PER 3. Kahl et al. (1977) found relationships between increased rate of gain and increased T3 and T4 levels. In this study, serum T3 more closely reflected treatment and weight gain than T4 which differs from Kahl et al. (1977). Baccari et al. (1983) showed strong correlations (r=0.91) between T3 and weight gain in heifers which would more closely agree with our study.

Supplementation did not consistently affect any of the blood variables. Forage crude protein remained above 6.5% throughout this study (Pitts 1989) and steers were probably able to select diets adequate in crude protein. This would explain the lack of response in ADG among treatments and would probably account for the lack of significant effects of supplementation on the measured blood constituents.

Inconsistencies in the relationships between blood constituents and ADG among periods were evident. Serum T3 and T4 exhibited a random relationship to ADG and NEFA was nonsignificantly related to ADG during all periods. Serum GLU appeared to parallel declining forage quality irrespective of steer performance. Inconsistencies in the relationships among blood components and ADG indicate that other factors were involved that could not be associated with relationships among blood constituents and performance.

Relationships between blood constituents and declining dietary quality were observed, however, no consistent relationship was evident among the blood parameters and animal gains. Predictive equations were developed by period but coefficients of determination were less than 0.48 and error of the predictions was over 0.22. The lack of similarity in response among different periods may reflect environmental changes and forage quality changes as well as inherent changes resulting from steer maturation. Trends observed in this study between blood constituents and diet quality would warrant further investigation into this relationship. A performance response to supplementation may be observed during periods of drought and during late summer and winter months. Separation of performance among supplemented groups of steers should provide better relationships between the observed blood constituents and ADG.

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