A Factorial Approach to Energy Supplementation for Grazing Beef Cattle

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Introduction

Beef cattle production in Florida is based upon the utilization of grazed forage. This forage base is a dynamic source of nutrients, particularly energy. The variation in energy content of the forage is affected by a number of factors (stage of growth, fertilization, precipitation, etc). The amount of forage available for grazing also fluctuates throughout the year. Therefore, differences in forage availability also constitute another variable affecting forage nutrient availability. Due to the variation of forage energy content and forage availability, grazed forage often does not meet the energy requirements or desired rate of performance of the beef cattle grazing the forage (Moore et al. 1999). To exasperate a difficult situation, the energy requirements of the grazing cattle change during the year based upon stage of production. However, the energy requirements of grazing cattle are not well documented (Caton and Dhuyvetter, 1997). The combination of changing forage chemical composition and thus energy availability and changing beef cattle requirements presents a challenging environment in which to provide adequate nutrition.

Important Forage Factors

As previously mentioned, the forage base is one of the two key factors affecting the energy supply and subsequent supplementation of grazing beef cattle. Forage chemical composition and forage intake potential are interrelated and important variables affecting cow energy supply. Forage chemical composition varies throughout the year. In Florida our predominate forage utilized for grazing is bahiagrass. Warm season grasses such as bahiagrass are generally low in energy (Garces-Yepez et al. 1997). Brown and Kalmbacher (1998) summarized TDN and CP content of central and south Florida bahiagrass. Likewise, US Sugar Corp. has amassed an extensive database of bahiagrass chemical composition. Combined these data offer an opportunity to review the extent of energy content variation on a monthly basis in bahiagrass. Energy content of bahiagrass (Table 1) has a range of about 7% TDN or 0.15 Mcal/lb of net energy of maintenance (NE_M). Other chemical characteristics that are important for the estimation of intake potential (ADF, NDF, CP, etc) vary to a greater extent throughout the year. Coupled together, the variation of energy content and intake potential can significantly affect the forage energy availability for grazing cattle.

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In Table 2, the differences in energy supply potential utilizing different intake prediction equations are presented. This table alone should be sufficient evidence for the challenge of predicting and meeting grazing cattle energy supplies. All the equations incorporate some forage factor in their calculation. The Moore and Kunkle (1999) equation incorporates crude protein, TDN, and acid detergent fiber (ADF). Similar to the Moore and Kunkle equation, the CP-ADF equation utilizes crude protein and ADF. The NRC equation in contrast, utilizes shrunk bodyweight and NE_M of the diet. While there is similarity in the input variables between the Moore and Kunkle and CP-ADF equation, these equations had the largest difference in predicted intake and subsequent energy intake.

Across all prediction intake equations, predicted forage intake is lowest in January. The prediction intake equations predict intake as a percent of bodyweight, assuming a January 1 calving date, the cow's bodyweight is at its annual low point because of the recent loss of the calf and products of conception. The low intake results in the minimal NE_M and NE_L intakes in January. This low energy intake corresponds to the occurrence of increased energy requirements.

Cow Energy Requirements-A Three Part Story

Cow energy requirements change throughout the year. The requirement for energy by the mature cow is a dynamic situation because the production cycle is not static. At no point in a yearly production cycle does a cow experience only maintenance energy requirements. We may say that "a cow is just maintaining herself", but if she is a productive member of the herd more than maintenance is occurring on a daily basis. Maintenance is defined as the amount of feed energy intake that will result in no net loss or gain of energy from the tissues of the cow's body (NRC, 1996). In reality a cow must always be adding or subtracting energy from her body tissues. The additive functions to maintenance include; growth, gestation, and lactation. The result of all ongoing energetic functions results in the total energy requirement of the cow.

Maintenance

Interestingly enough the NRC does not consider all maintenance equal. Table 3 presents a 5 year-old, body condition score 5, mature bodyweight (BW) 1,175 lb, peak milk production of 16 lb/d at 8.5 weeks after calving mature Brangus cow's energy requirements on a monthly basis. There exists two distinct phases of NE_M requirements; that during the lactation period and that during the dry period. About a 20% difference (NRC, 1996) exists between these two periods. This increased in maintenance energy requirement associated with lactation is due to the increased metabolic demand upon body tissues, not the product (milk) result of lactation. Additionally, the initial NE_M does not account for any energy expenditure for activity associated with grazing. The difference in maintenance energy requirements for grazing cattle could be from 10 to 50% depending upon the grazing conditions and forage availability.

Lactation

The net energy of lactation (NE_L) requirement expressed for lactation is a function of milk yield, milk fat %, and milk protein %. The previously mentioned variables change during the lactation cycle, and thus the energy requirement of lactation changes accordingly. In the monthly energy requirements (Table 3) peak lactation energy requirement occurs during the second month postpartum. Identified differences between and within breeds that affect milk yield and milk composition also affect the lactation energy requirement. Unlike other energy requirements, lactation has a rapid onset of demand for energy that is initiated by parturition. Development of mammary tissues occur prepartum, but the majority of the lactation energy requirement is associated with milk production.

Gestation

The energy requirement associated with pregnancy is an underlying energetic demand for 10 out of 12 months during the yearly production cycle. Whereas the energy required for gestation is initially very small, just 0.1% of the NE_M during the third month postpartum. In contrast, the gestation energy requirement one month prior to parturition is approximately 56% of the NE_M requirement during the same time. The post-weaning period is often referred to as a “maintenance period” for the grazing beef cow. Indeed, gestational requirements at weaning (3% of total energy required) do not equate to the greater energetic demand of lactation (17% of total energy demand), however this is an important energetic supply and demand period. This period is utilized for growth of the products of conception.

Growth

Growth in the case of the mature cow herd can be construed as the recovery of body tissue energy (i.e. bodyweight and body condition) not associated with the products of conception. During a small time period after the cessation of lactation and prior to the accelerated fetal growth, additional energy supplied to the cow can be utilized for growth of body tissues. This growth is utilized to regain lost bodyweight and body condition score due to the mobilization of body tissues during lactation. These accreted body tissues will most likely be re-utilized at some point during the production cycle to support maintenance or lactation.

Energy Balance of Grazing Cows

The energy supplied by the forage diet (Table 2) and the energy required by the grazing cow (Table 3) result in the monthly energy balance (Table 4). The basic premises of a factorial approach to energy supplementation are:

1. There is a hierarchical portioning of energy use in the cow’s body.
2. Maintenance energy requirements are met first.
3. Subsequent energy requirements (lactation, gestation, growth) are met with any remaining energy supply.

4. Supplemental energy will be utilized to meet any deficiency in maintenance energy supply, then to meet productive energy requirements.

Examination of Table 4 indicates several months in which energy supplied by the grazed forage is deficient to meet maintenance energy requirements of the example cow. Figure 1 indicates the NE_M balance on a monthly basis. The variation in predicted intake and energy supply is apparent, especially in March through August. Particularly in those months where NE_M requirements are not met, lactation and gestational energy requirements are also not met.

A deficiency in energy supply indicates that either more feed is necessary or greater energy density in the ration is needed. Suppose that the predicted forage intake by any of the equations had no the maximal limit. If that were the case additional forage could be utilized to meet NE_M requirements of the cows. The amounts of forage needed to meet the NE_M requirement for each prediction equation in the month of January for the example cow would be an additional 4.8, 3.2, or 8.7 lbs (Moore and Kunkle, NRC, CP-ADF; respectively) of forage dry matter. Likewise in February, the energy deficiency of NE_M for the cow would necessitate additional energy input. In February the extra forage intake that would be needed is 0.7, 1.6, and 5.4 lbs of forage. Obviously, the forage energy supply is not sufficient to meet a lactating-grazing cow's energy requirements. However, since we believe that the prediction equations are accurately predicting maximal forage dry matter intake, there likely would not be sufficient intake capacity in January and February (first two months after parturition) for additional forage dry matter intake. As obviously shown in Table 2, predicted energy supply from forage alone varies among the three presented prediction equations. These prediction equations consider a number of chemical components that are not presented to arrive at the predicted dry matter intake. Accurate prediction of grazing cattle dry matter intake has been and continues to be a challenge to accurately asses. Obviously in production settings large, long-term energy deficiencies are not tolerated. More to the point, the NRC predicts for the example grazing cow that nominal monthly pasture conditions would result in a loss of one body condition score every 35 to 55 days from January through June without any input of additional energy. During this time period the energy requirements are too great and forage quality and availability are to limiting to achieve acceptable cow performance.

The alternative to additional forage dry matter intake is to provide additional energy in supplemental feeds. For demonstration purposes I have utilized four viable energy feedstuffs: corn, soybean hulls, corn gluten feed, and liquid molasses. An initial disclaimer, in the subsequent calculations I did not determine any substitution values for the additional feeds, the level of supplement was solely determined to meet the given energy deficit for NE_M, NE_L, or gestation, while predicted forage dry matter intake remained unchanged in spite of supplementation. Table 4 presents a basic indication as to which month energy supplementation will be required to meet maintenance, lactation, and gestation energy requirements. Differences in dry matter intake prediction do lead to some differences in energy supplied by the forage.

To meet the NE_M deficiency in January and February a more reasonable approach to supplemental energy can be accomplished with energy dense supplemental feeds. The quantity of supplemental feed will vary depending upon the predicted dry matter intake and NE_M concentration of the feedstuff. Table 5 presents the calculated amounts of corn, soybean hulls, corn gluten feed, and liquid molasses to meet the NE_M deficiency. As mentioned previously these amounts of supplemental feed are determined to meet the energy deficit. Given the nature of energy supplementation factors such as substitution, associative effects, and dietary protein adequacy are likely to have multiple impacts on forage dry matter intake and the resulting energy balance. Ultimately during the year cow, NE_M and NE_L requirements decrease and these energy requirements can be met entirely by the grazed forage according to the Moore and Kunkle equation in May and June and with minimal supplementation in June according to the NRC and CP-ADF equations.

Having met the NE_M requirements, the next priority in energy partitioning is lactation. In the factorial design all forage energy is first partitioned to meet NE_M requirements. In the case of January and February no forage would be available to meet NE_L requirements because of the NE_M deficiency. Therefore, all of the energy to support lactation would be derived from the supplemental feeds. Differences in supplemental feed amounts in January and February are therefore a result of differences in NE_L of the feeds. The feed supplement amounts to support lactation are presented in Table 5. In the subsequent months of March through June, an excess of NE_M exists in the forage. The excess NE_M allows some of the forage to be utilized to meet the NE_L requirements during the rest of lactation. The available excess forage from NE_M therefore decreases the amount of supplemental feed needed to support lactation (Table 5). Considering together the supplemental feed amounts for NE_M and NE_L, these sums would be similar to the feeding practices often observed during early lactation in grazing beef cows. During May and June, forage quality is adequate to support NE_M and NE_L requirements of the grazing beef cow.

Gestation is the final energy requirement to be met. The cow will maintain herself and current calf through lactation before expending energy for gestation. Gestation energy requirements begin in March (Table 3), and because of simultaneous NE_M and NE_L requirements, energy supplementation to support gestation would also occur in March. Gestational energy requirements are relatively low during the first trimester (March to May), indicating only a minor demand for energy supplementation to a grazing cow (Table 5). Depending upon which dry matter intake prediction equation is utilized dictates if forage alone can support gestational energy requirements during May and June. The equation developed by Moore and Kunkle indicates adequate forage in May and June to supply energy for gestation (Table 4). In contrast, the NRC and CP-ADF equations do not predict adequate forage intake in May and June to meet maintenance, lactation, and gestation energy requirements. Thus a slight energy deficiency is present indicating minimal energy supplementation is needed. From July through September adequate forage energy exists to meet both maintenance and gestation requirements. However, during the last trimester gestation energy demands increase and can not be met by grazed forage alone. In fact, gestational energy demands just prior to parturition can nearly equal those of early lactation. The increase in energy requirement associated with pregnancy would necessitate the initiation of energy supplementation to the grazing-gestating beef cow.

Forage Supplement Interaction

As previously mentioned, the calculated supplement amounts to meet energy requirements in this paper do not consider the interaction of the forage and supplement. However, acknowledgement of that interaction should be addressed. One should refer tot the work of Moore et al. (1999) to examine the interaction of supplement type and forage type on animal intake. In their review, Moore et al. (1999) indicated that forage intake was both increased and decreased with supplementation. These authors reported that much of the negative effect on forage dry matter intake (substitution) occurred when forage TDN:crude protein was < 7, whereas a TDN:crude protein > 7 likely indicates a nitrogen deficit in the forage. This nitrogen deficit likely affects forage intake, digestibility, and thus forage energy value. Marston and Lusby (1995) indicated that once protein requirements within the diet are met, increasing energy intake by feeding supplementation would be difficult without substitution. Consideration of the forage-supplement interaction needs to be fully addressed in practical feeding situations.

Conclusions

Our current inability to wholly and accurately predict grazing cattle forage intake impairs our ability to accurately assess and meet the energy requirements of cow. The combined variances of forage supply, forage quality, and animal requirements during the year present a matrix of scenarios that increases the difficulty of accessing energy balance in cattle. In Florida the same environmental factors that affect forage growth also affect cow-calf management. Movement of the calving season to more closely match cow energy requirements to forage energy availability presents other serious management considerations. The consequence of not matching energy supply and demand necessitates energy supplementation to our cow herd. Altering the energy status of cows in productive settings presents particular challenges throughout the year including forage energy concentration, intake potential and supplement type. In addition, characteristics not addressed in this paper; associative effects will affect forage dry matter intake and energy intake, and ultimately cow energy balance.

Acknowledgements

The author would like to thank Dr. Chet Fields of US Sugar Corp. for graciously sharing information concerning their accumulated bahiagrass chemical composition database and nutritional adequacy spreadsheets. These resources greatly facilitated accomplishment of this work.

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Table 1. Monthly cow body weight and predicted intake potential [a]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
BW, lb	1175	1175	1177	1178	1180	1183	1189	1198	1211	1230	1258	1296
Intake Potential, % BW												
Moore & Knunkle	1.97	2.16	2.23	2.33	2.50	2.45	2.46	2.28	2.18	2.10	2.12	2.08
NRC	2.11	2.08	2.06	2.06	2.04	2.09	2.08	2.08	2.09	2.11	2.11	2.10
CP-ADF	1.64	1.76	1.84	2.07	2.14	2.11	2.04	1.85	1.78	1.71	1.75	1.70

[a] Mature Brangus cow, mature body weight 1,175 lb. Calving date January 1, calf birth weight 75 lb.

Table 2. Monthly energy supplied by different intake predictions [a]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Moore & Knunkle							Mcal/d					
NE_M	9.3	10.9	14.0	14.2	15.5	14.8	15.1	13.1	12.9	12.1	11.8	11.8
NE_L	6.9	8.9	10.8	11.9	13.5	12.6	11.7	11.9	9.9	9.5	9.2	9.6
NE_G	3.7	4.6	7.3	7.3	8.0	7.5	7.7	6.9	6.5	5.6	5.1	5.0
NRC												
NE_M	12.3	12.5	14.2	13.8	13.8	14.0	14.1	13.9	13.9	13.9	13.8	14.1
NE_L	7.4	8.6	9.9	10.5	11.0	10.7	9.9	9.9	9.6	9.5	9.2	9.7
NE_G	3.9	4.5	6.7	6.4	6.6	6.4	6.5	6.3	6.2	5.6	5.1	5.0
CP-ADF												
NE_M	9.6	10.6	12.7	13.9	14.5	14.1	13.8	12.4	11.9	11.3	11.5	11.5
NE_L	5.8	7.2	8.9	10.6	11.5	10.8	9.7	8.8	8.1	7.7	7.6	7.8
NE_G	3.1	3.8	6.0	6.5	6.9	6.5	6.4	5.6	5.3	4.5	4.2	4.1

[a] Mature Brangus cow, mature body weight 1,175 lb
Bahiagrass diet mean of Brown and Kalmbacher (1998) and US Sugar Corp. bahiagrass data base.

Table 3. Monthly energy requirement of grazing beef cow [a]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
						Mcal/d						
Maint. [b]	11.20	11.20	11.20	11.20	11.20	11.20	9.34	9.34	9.34	9.34	9.34	9.34
Lactation	4.61	5.54	4.98	3.98	2.99	2.15	0.00	0.00	0.00	0.00	0.00	0.00
Gestation	0.00	0.00	0.01	0.03	0.06	0.13	0.28	0.54	1.01	1.77	2.93	4.57
Total	15.81	16.74	16.19	15.21	14.25	13.48	9.62	9.88	10.35	11.11	12.27	13.91

[a] Mature Brangus cow, mature body weight 1,175 lb.; Calving date January 1; calf birth weight 75 lb; peak milk yield = 17 lb; peak milk = 8.5 weeks.
[b] 15% increase of NE_M requirement because of grazing status.

Table 4. Months needing energy supplementation to meet requirements

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Maintenance [a]												
Moore & Kunkle	X	X										
NRC	X	X										
CP-ADF	X	X										
Lactation [b]												
Moore & Kunkle	X	X	X	X								
NRC	X	X	X	X								
CP-ADF	X	X	X	X								
Gestation [c]												
Moore & Kunkle			X	X						X	X	X
NRC			X	X	X	X				X	X	X
CP-ADF			X	X	X	X				X	X	X

[a] Months indicated by a deficiency of NE_M supplied by forage to meet maintenance requirement..
[b] Months indicated by a deficiency of NE_M for residual energy and/or NE_L supplied by forage to meet location requirement..
[c] Months indicated by a deficiency of NE_M for residual energy and/or NE_G supplied by forage to meet gestation requirement.

Table 5. Mean supplement amounts needed to meet monthly energy deficiencies in grazing beef cows

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Maintenance												
Corn	2.25	1.11										
SBH	2.53	1.26										
CGF	2.53	1.26										
Molasses	2.89	1.44										
Lactation												
Corn	5.34	6.73	4.29	2.75								
SBH	6.55	7.87	5.26	3.37								
CGF	5.43	6.53	4.36	2.79								
Molasses	6.31	7.58	5.06	3.24								
Gestation												
Corn			0.02	0.04	0.09	0.19				1.25	2.75	5.17
SBH			0.02	0.05	0.10	0.22				1.38	2.97	5.58
CGF			0.02	0.05	0.10	0.22				1.42	3.12	5.87
Molasses			0.02	0.06	0.12	0.27				1.67	3.60	6.77

Figuere 1. Monthly cow NE_M balance for different intake prediction equations