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Low Cost Cow/Calf Program: The School – Part IV

In this issue we will present Dr. Dick Diven's (Agri-Concepts, Inc.) discussion on protein, what it is, the different forms of, and its relation to Net Energy maintenance (NEm) with regard to how much the animal needs.

The Essence of Life

Proteins are found in all living cells and have various biological functions. There are enzyme proteins that catalyze cellular reactions; the structural proteins collagen, keratin and elastin; transport proteins (e.g. hemoglobin); nutrient proteins (e.g. casein); proteins that are antibodies necessary for immunity; hormones which regulate metabolism; and contractile muscle proteins (e.g. actin and myosin) that perform mechanical work. Proteins are synthesized by living organisms and are made up of one or more chains of amino acids (20 kinds) known as the building blocks of proteins. Amino acids are small molecules containing an amino group (NH_2), a carboxyl group (COOH), and a side chain which determines the chemical properties. These side chains may contain phosphorus or other metals such as iron, zinc and copper.

The linkage between amino acids is called a peptide bond and chains of up to about 50 amino acids are known as peptides whereas those of over 50 amino acids are referred to as proteins (aka polypeptides).

Plant and animal proteins consist of the same amino acids. However, plants are able to synthesize all twenty amino acids using nitrogen and water from the soil and carbon dioxide from the air, whereas animals are able to synthesize only ten kinds of amino acids to meet their needs. The synthesized amino acids are referred to as non-essential as the animal does not need to obtain them from their food, whereas the non-synthesized ones are considered as essential and the animal must obtain them from the food they eat.

Plant leaves contain the highest amount of protein (young leaves up to 25%), seeds moderate amounts (8% to 14%) and stems very little. Mature dormant vegetation can contain less than 4% protein and some of it is not digestible by even ruminant animals because of the presence of lignin.

As indicated above, amino acids contain nitrogen (from NH_2), thus so does protein. Most plant proteins contain an average of 16% nitrogen (N). However, protein from wheat contains an average of 17.5% N. Protein content of plant material is calculated from its N content which is determined by laboratory analysis (Kjeldahl method). For every 1% N plant material contains its protein content is 6.25%, (1 ÷ 16 * 100). Thus plant material that contains 1.5% N has a calculated protein content of 9.4%, (1.5 * 6.25). Because some portion of the N in plant material is from non-protein nitrogen (NPN) the value calculated by multiplying N x 6.25 is referred to as crude protein rather than true protein.

When feed consumed by a ruminant animal enters its rumen it is attacked by the rumen microorganisms (bacteria, fungi, and protozoa). These microbes break the feed protein down to its simplest forms – amino acids, carbon chains, single carbon atoms in the form of methane (CH_4), free nitrogen atoms in the form of ammonia (NH_3) and a few other simple molecules. The microbes are able to break the peptide bonds of proteins whereas these bonds are not able to be broken by normal digestive processes of the animal.

Plant protein the rumen microbes attack and break down is termed **degradable intake protein (DIP)** and is utilized **only** by the rumen microbes. Ruminant animals are not able to use DIP so in order for them to benefit from this protein it has to be converted into another form known as **microbial protein (aka Metabolizable protein)**.

Unlike animals rumen bacteria and protozoa do not have sophisticated digestive systems. They are not able to synthesize free amino acids into protein. They have to actually make amino acids which they then link together to form their own protein. They take the simple molecules of carbon, carbon chains and ammonia they have liberated from the feed the animal has consumed and build amino acids from them. They then assimilate these amino acids into their own characteristic protein that perform similar functions within them as does protein in animals. The protein content of rumen microbes is 55% to 60% (USDA ARS 2007, Moran 2005). This is important as it is the rumen microbes themselves that are the primary source of protein for the animal.

When rumen bacteria and protozoa pass from the rumen into the abomasum and on into the intestine they are digested. Their body protein is metabolized into amino acids by the animal's digestive system. These amino acids move across the intestinal wall and are then recombined (linked) together to form animal protein.

Not all the protein found in forages and grains consumed by the ruminant animal is degraded by the rumen microorganisms. Some plant proteins escape microbial attack or are not degradable by the microbes and are washed down the digestive tract to the abomasum and intestines. These **escape and bypass proteins** (aka Undegradable Intake Protein) are directly utilized by the animal, thus the ruminant animal has two sources of protein – microbial and escape. For our purposes we will refer to all protein that is not degraded as escape.

Degradable Intake Protein

For ruminant animals whose main source of feed is forages it is critical that there is a sufficient amount of DIP to meet the rumen microbes' needs so that in turn the animal's protein requirements and its energy needs are met. A healthy and productive rumen bacteria and protozoa population is needed to effectively ferment the cellulose and starch found in forages and convert it to Net Energy maintenance (NEm) for both the microbes and the ruminant animal. Thus the ruminant's diet must contain an adequate amount of DIP to meet the microorganisms' requirements for growth and reproduction. *Recall from Part II (February 2010 issue) that fatty acids produced from the fermentation of cellulose, sugars and starches are the energy source for both the ruminant animal and the rumen microorganisms.*

As with energy the protein needs of the rumen microorganisms needs to be met before the protein needs of the ruminant animal can be met. The amount of DIP needed by the microbes is related to how much fermentable energy (NEm) is available to them. Dr. Diven indicated that the amount of DIP (lb/day) required in the diet of a beef cow was 10% of the amount of NEm (Mcal/day) she consumed (NRC 1985). However, further research in this area has found that the relationship is closer to 1:7.7 or 13% (NRC 1996, Poland 2000). Thus for every Mcal of NEm a cow consumes the feed or forage needs to contain at least 0.13 lb of DIP to meet the rumen microorganisms' protein needs.

Dr. Diven also pointed out, that very low levels of NEm consumption result from either low quality forage (<3% crude protein & >80% neutral detergent fiber, Wiedmeier, et al. 2008) or low forage availability. In either case, the animal is starving and no amount of protein supplementation will rectify the problem. The NEm needs of the microbes have to be met first. If forage quality is low but not as poor as that above and there is plenty of it, furnishing the animals a protein supplement is warranted and what needs to be determined is the minimum required amount.

As mentioned above not all plant protein ingested by the animal is DIP but for forages the majority is. Dr. Diven stated that approximately 80% of the protein contained in forage will be degraded to ammonia and other simple molecules. The other 20% that escapes degradation in the rumen is digested by the animal itself as pointed out previously. The importance for understanding this will become obvious as we determine what the range forage is providing the animal compared to its needs and that of the rumen microorganisms.

We know that the crude protein (CP) content of plants declines as they mature and go dormant and that legumes (e.g. alfalfa) contain more than grasses. In addition, cool season grasses generally contain more CP compared to warm season grasses at the same growth stages. These relationships also apply to DIP. The CP content of green, growing grass in the spring can be as much as 90% DIP, whereas, for dormant winter grass it can be as low as 63% (NRC 1996). The portion of CP in alfalfa that is DIP can range from 75% for late bloom hay to 88% for 10th bloom hay. And as most hay producers and livestock owners know 10th bloom hay contains more CP than late bloom hay (≈ 20% vs. ≈ 12%, respectively).

Another hay that is common in Wyoming is that from either smooth or meadow bromegrass. The CP content of brome hay can range from 16% for pre-bloom to 6% for mature (NRC 1996). Pre-bloom brome has seedheads emerged but anthesis (flowering) has not occurred whereas in mature brome the seeds have developed. Generally in NE Wyoming the timing of these stages is from early June to mid-July. The amount of CP that is degradable for these maturities is 79% and 48%, respectively. The importance of these differences will become obvious in the next installment of this series.

Dr. Diven showed a chart that depicted the DIP and escape protein contents of range grasses collected from various cooperating ranches of his program. As done in Part II of this series for NEm, average crude protein content of range grasses from five Johnson County ranches is shown in Figure 1. Although a laboratory analysis to determine the portion of crude protein that was DIP was not done values from NRC 1996, Appendix Table 1, were used: 63% for Dec – Mar; 70% for Apr and Oct; 90% for May; and 80% for Jun – Oct; annual average 74%. Using a DIP value of 80% would probably be too high for winter range grass where determination of protein supplement needs is critical.

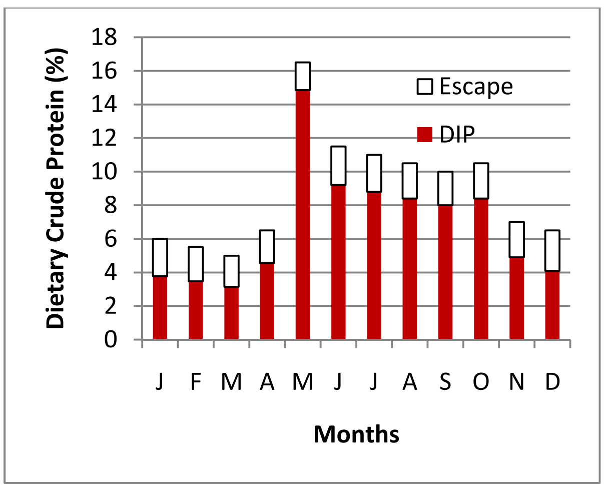

Figure 1: Degradable Intake Protein (DIP) and Escape protein contents (together = diet crude protein) of range grasses from five Johnson County, Wyoming ranches.

Dr. Devin asks the question from his data – Is there sufficient DIP throughout the year to afford the microorganisms the opportunity for maximum utilization of the available NEm? If there is not a sufficient amount of DIP then the rumen microbes will not be able to utilize all of the available NEm and thus the cow will also not receive as much energy from the feed as she would otherwise. Remember the rumen microbes are not able to use escape protein just DIP to meet their protein needs.

Dr. Diven also displayed a chart showing NEm content of the range grasses. Figure 2 is from Part II and shows the NEm amounts from the Johnson County ranches.

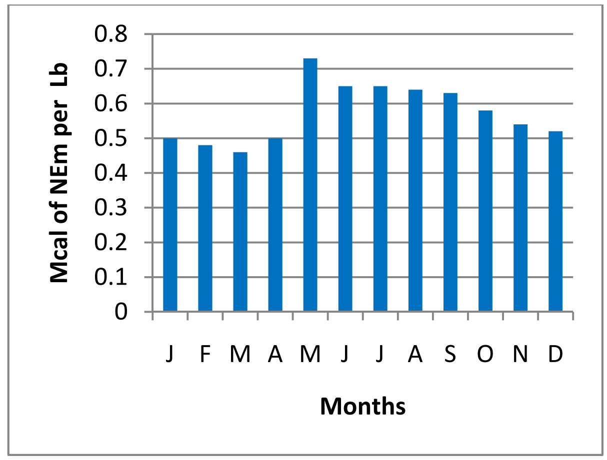

Figure 2: Net Energy maintenance (NEm) content of range grasses from five Johnson County, Wyoming ranches.

There is a similar pattern for protein and NEm contents of the range grass although protein levels appear to be more adversely affected with grass maturity and dormancy. So, is there enough DIP in the grasses throughout the year to allow the rumen microbes to fully utilize the available NEm? Let's determine if there is or is not. How is this done?

Remember for every Mcal of NEm available to the microbes they need 0.13 lb DIP. So if January range grasses from the five Johnson County ranches averaged 0.50 Mcal NEm/lb there needs to be 0.065 lb of DIP (0.50 * 0.13). If the DIP content of the grasses averaged 3.8% (6% CP * 0.63) that is equivalent to 0.038 lb (3.8 ÷ 100) DIP. Subtracting 0.038 lb from 0.066 lb results in a shortfall of 0.028 lb of DIP for each pound of range grass consumed (dry matter basis). This 0.03 lb DIP would need to be supplied to the cow in a protein supplement so that the rumen microbes could fully utilize the available NEm for their and the cows benefit.

Figure 3 shows that the range grasses do not contain an adequate amount of DIP to meet rumen microbe needs based on grass NEm content from November – April. As a result a protein supplement would need to be provided the cow to satisfy rumen microbe DIP needs. How much supplemental protein should be provided the cow – enough only to meet the rumen microorganisms' DIP needs? That is dependent upon the cow's size and her stage of production which will be discussed in the next issue. However, Table 1 shows how much DIP an 1175 EMBW non-lactating cow will consume from the range grasses and how much the microbes need. This provides the rancher an idea as to whether his/her cows' protein needs are being met by whether the microbes' DIP requirement is being satisfied.

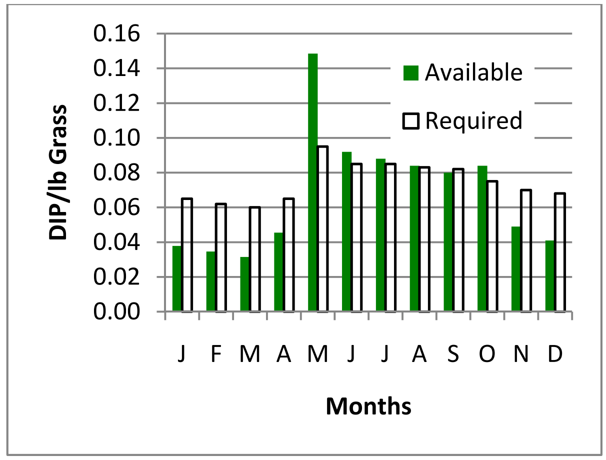

Figure 3: Amount of Degradable Intake Protein (DIP) available in the forage and amount required to meet rumen microbe needs based on forage NEm content.

Table 1: Relating Net Energy maintenance (NEm) utilization to Degradable Intake Protein (DIP) availability for an 1175 Empty Mature Body Weight (EMBW) non-lactating beef cow.

Month	Mcal NEm/lb	%CP[1] in diet	DIP %CP	Lb DIP /Mcal[2]	Mcal NEm consumed[3]	Lb DIP Available[4]	Lb DIP Required[5]	DIP ±[6]
Jan	0.50	6.0	63	0.076	12.7	0.96	1.65	-0.69
Feb	0.48	5.5	63	0.072	11.6	0.84	1.51	-0.67
Mar	0.46	5.0	63	0.068	10.7	0.73	1.39	-0.66
Apr	0.50	6.5	70	0.091	12.7	1.15	1.65	-0.49
May	0.73	16.5	90	0.203	26.0	5.29	3.38	1.91
Jun	0.65	11.5	80	0.142	21.0	2.97	2.73	0.24
Jul	0.65	11.0	80	0.135	21.0	2.84	2.73	0.11
Aug	0.64	10.5	80	0.131	20.4	2.68	2.65	0.03
Sep	0.63	10.0	80	0.127	19.8	2.51	2.57	-0.06
Oct	0.58	10.5	80	0.145	16.9	2.45	2.20	0.25
Nov	0.54	7.0	70	0.091	14.7	1.34	1.92	-0.58
Dec	0.52	6.5	63	0.079	13.7	1.08	1.78	-0.70

[1]%CP (Crude protein) in diet generally averages 1% to 2% higher than laboratory analysis, thus the 1.5% has been added to the laboratory averages. (Difference does not apply to NEm)

[2]Lb DIP/Mcal: (%CP ÷ Mcal NEm/lb) ÷ 100 * DIP %CP ÷ 100.

Ex. for Jan: 6.0 ÷ 0.50 = 12.0 ÷ 100 = 0.12 * 63 = 7.56 ÷ 100 = 0.0756

[3]Mcal NEm consumed: $(0.65 * \text{EMBW})^{.75} * (0.144598 * \text{NEm/lb} + 0.206865 * \text{NEm}^2 - 0.036915$. Ex: $(0.65 * 1175)^{.75} = 145.3$ (Metabolic weight for this cow)

Ex. for Jan: $145.3 * (0.144598 * 0.50 + 0.206865 * 0.50^2 - 0.036915) =$

$145.3 * (0.072299 + 0.05171625 - 0.036915) = 145.3 * 0.0871 = 12.656$

[4]Lb DIP Available: Lb DIP/Mcal * Mcal NEm consumed. Ex. for Jan: 0.0756 * 12.656 = 0.96

[5]Lb DIP Required: Mcal NEm consumed * 0.13. Ex. for Jan: 12.7 * 0.13 = 1.65

[6]DIP ±: Lb DIP Available – Required. Ex. for Jan: 0.96 – 1.65 = -0.69

Forage that contains at least 6% crude protein (potentially 1.25 to 1.75 lb/day depending on cow size) generally is considered to be sufficient to meet the needs of a non-lactating beef cow. Thus, the range grasses from the five Johnson County ranches would appear to contain an adequate amount of crude protein in the months of Jan, Apr, Nov, and Dec to meet a cow's needs. However, due to the amount of NEm present in the grasses there is not an adequate amount of DIP to meet the rumen microorganisms' needs and thus they will not be able to fully utilize the available energy. This would negatively affect the amount of microbial (Metabolizable) protein available to the cow, thus potentially resulting in reduced animal performance. Dr. Diven indicated that if the DIP deficit amount is divided by the required amount the result is the level of reduced animal performance. Thus a cow's performance would be potentially reduced by 30% (Nov: [-0.58÷1.92]*100) to 47% (Mar: [-0.66÷1.39]*100) based on the Mcal NEm and lb DIP consumed by the cow. What exactly that means I'm not sure but most likely the cow will lose more body weight than desired; if pregnant could possibly result in reduced calf birth weight; if in lactation less milk affecting calf performance and more difficulty in rebreeding. None of these scenarios are desirable for the rancher and thus the importance of providing a protein supplement to make up for the deficit.

If the amount of DIP consumed by the ruminant animal is in excess of that amount the rumen microorganisms can use it is excreted. There is no harm to the animal. A sign that the amount of DIP the animal is consuming is more than needed by the rumen microbes and as a result itself, is that their manure is runny. This is especially noticeable in cattle.

In the next installment we will present Dr. Diven's discussion on the urea cycle, protein supplements including hay that can be used to make up a degradable intake protein deficit, and the protein requirements' for the animal. Providing an adequate amount of a DIP supplement to ensure the needs of the rumen microbes' is met does not necessarily mean the ruminant animal's needs are met.

Literature Cited

Moran, J. 2005. How the rumen works. Tropical dairy farming: Feeding management for small dairy farmers in the humid tropics. Collingwood, Victoria, Australia: Landlinks Press; pp. 41-49.

NRC. 1984. Nutrient requirements of beef cattle (6th Ed.). National Academy Press, Washington, DC.

NRC. 1985. Ruminant nitrogen usage. National Academy Press, Washington, DC.

NRC. 1996. Nutrient requirements of beef cattle (7th Ed.). National Academy Press, Washington, DC.

Poland, C. 2000. NRC nutrient requirements for beef cows. Ext. Bull. 74. Dickinson Research Extension Center, North Dakota State University, Dickinson, ND.

Weimer, P. 2007. Rumen microbes: Take a closer look at these interesting creatures that both work for and feed dairy cattle. Fact Sheet. USDA ARS U.S. Dairy Forage Research Center, Madison, WI.

Wiedmeier, R.D., D. R. ZoBell, and C. Burrell. 2009. Ammoniation and use of ammoniated low quality roughages. Cow-Calf Management Guide, CL382. Western Beef Resource Committee, University of Idaho, Moscow, ID.

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