Protein Supplementation

Jim E. Sprinkle

Introduction

Much of Arizona can be characterized as having a bimodal (occurring twice per year) pattern of forage production which accompanies the seasonal summer monsoons and winter rains or snows. Forage quantity and quality decreases during the winter dormant season and the “summer slump” preceding summer rains (Figure 1). However, forage quality during any given month can be quite variable, depending upon the timing, frequency, amount of moisture, and the forage type selected. This is illustrated in the following table.

Table 1. Range in Crude Protein by Month

<table>
<thead>
<tr>
<th>Month of Year</th>
<th>Number of Observations</th>
<th>Crude Protein, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>2</td>
<td>3.94 - 7.55</td>
</tr>
<tr>
<td>February</td>
<td>5</td>
<td>1.58 - 6.9</td>
</tr>
<tr>
<td>March</td>
<td>3</td>
<td>2.57 - 7.3</td>
</tr>
<tr>
<td>April</td>
<td>3</td>
<td>4.55 - 7.9</td>
</tr>
<tr>
<td>May</td>
<td>5</td>
<td>1.92 - 9.3</td>
</tr>
<tr>
<td>June</td>
<td>3</td>
<td>5.59 - 9.0</td>
</tr>
<tr>
<td>July</td>
<td>4</td>
<td>4.45 - 8.6</td>
</tr>
<tr>
<td>August</td>
<td>6</td>
<td>4.42 - 9.43</td>
</tr>
<tr>
<td>September</td>
<td>4</td>
<td>4.78 - 12.5</td>
</tr>
<tr>
<td>October</td>
<td>2</td>
<td>8.0 - 7.4</td>
</tr>
<tr>
<td>November</td>
<td>7</td>
<td>3.03 - 6.7</td>
</tr>
<tr>
<td>December</td>
<td>2</td>
<td>4.5 - 7.13</td>
</tr>
</tbody>
</table>

Providing supplemental protein when crude protein is less than 6.25% can increase forage intake and sometimes forage digestibility, reduce weight loss before calving, and ultimately increase conception rate and profitability.

If the Total Digestible Nutrients (TDN) of forage is around 52 to 55%, forage intake required to maintain a nonlactating cow is around 1.8 to 2.1% of body weight or 18 to 20 lbs. This is true whether protein requirements are being met by the forage or by feeding supplemental protein. If protein is deficient in the diet, severe weight loss can occur because the cow must break down body tissue to supply the necessary protein. It takes 6.7 lbs. of lean tissue to supply 1 lb. of protein (Berg and Butterfield, 1976). Conversely, if the diet is deficient in energy (TDN), this only requires 1 lb. of body weight loss for each 1 lb. of TDN (NRC, 1989). As shown in the graph above, when forage fails to meet protein requirements of the microbes in the rumen, intake decreases. This is because microbe numbers and/or microbe activity decrease, reducing forage digestibility.

Determining When to Supplement Protein

Generally speaking, crude protein content required in the forage to meet the requirements of ruminal microbes which digest fiber is around 7%. When crude protein in forage is below around 6.25%, forage intake for the nonlactating cow drops sharply (Figure 2).
and increasing exit time from the rumen for fiber. When the forage only contains 4% crude protein, the above graph projects forage intake of only 1.2% of body weight. Forage intake at this level would cause extreme weight loss. Ignoring deficient protein and only considering the energy deficit, weight loss in the above example could exceed 4 lbs. per day.

As a general rule, do not supplement protein when the forage contains greater than 6.25% crude protein (Caton et al., 1988). However, benefits will be gained by protein supplementation when crude protein in forage is low. This principle is illustrated by the tables below. In the first example (Table 2), forage intake and overall nutrient intake increased by 27% when steers on a 6% crude protein hay diet received additional protein. In the second example (Table 3), supplementing steers grazing tobosa grass was only beneficial when the forage contained less than 7% crude protein.

Obviously, the only way to decide whether you need to supplement crude protein is to test forage for protein content. Your local Extension office can provide a list of commercial labs that perform this service. The cost for crude protein and TDN analyses totals around $25. Alternatively, near infrared spectroscopy (NIRS) analyses can be performed on fecal samples, provided the cow’s diet does not exceed 30% browse. This service is provided by Texas A&M University Grazingland Animal Nutrition Lab at Temple, TX (phone 254-774-6134; http://cnrit.tamu.edu/ganlab/).

It should be mentioned that protein supplementation is only effective when an adequate quantity of forage is available. The strategy when supplementing protein is to feed the microbes enough protein to enable the cow to more effectively process and harvest cheap low-quality forage. When forage utilization (removal of available quantity by livestock, wildlife, and insects) exceeds 50% of the total mass, protein supplementation may be ineffective and expensive. In this scenario, it would be more advantageous to feed a combination protein/energy supplement. The next two graphs support this point. In the first graph (Figure 3), researchers found that maximum animal gain per acre was achieved when forage utilization was 40 to 50%. Animal performance dropped sharply when forage utilization reached the 60% level. The standard rule of range management for plant health is “to take ½ and leave ½”. This is also good animal management. In the second graph (Figure 4), an experiment was conducted with protein supplementation on mid-grass prairie at two different stocking rates. In the heavy stocking rate regimen, protein supplementation was not economically sound.

The ideal time to supplement protein in terms of a cow’s physiological cycle is 60 to 90 days before calving. This is the time period when maintenance requirements are low and you receive the biggest “bang for your buck” in preventing weight loss and increasing conception rate. In most of Arizona with traditional spring calving, this accompanies the forage winter dormancy period. It is an expensive proposition to try to put on weight after calving as Mother Nature is working against you. The demands of early lactation induce weight loss, which is almost impossible to reverse until after about day 45 to 60 of lactation. It is a more cost-effective practice to have the cow maintain or put on weight before calving to provide a safety cushion for weight loss. The table below illustrates the importance of having cattle in good body condition at calving.

<table>
<thead>
<tr>
<th>Experimental Group</th>
<th>Rumen Digestibility</th>
<th>Forage Intake Increase</th>
<th>Net Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplemented</td>
<td>57%</td>
<td>+ 27%</td>
<td>+ 9% increase in nutrient utilization</td>
</tr>
<tr>
<td>Control</td>
<td>48.8%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Cottonseed Meal Supplementation

Steers Fed 6% Crude Protein Prairie Hay

<table>
<thead>
<tr>
<th>Year</th>
<th>Amount</th>
<th>144 lbs</th>
<th>ADG</th>
<th>Extra Gain</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>0.00</td>
<td>0.00</td>
<td>0.84</td>
<td>1.48</td>
<td>0.64</td>
</tr>
<tr>
<td>1986</td>
<td>0.00</td>
<td>1.43</td>
<td>1.13</td>
<td>0.00</td>
<td>0.14</td>
</tr>
<tr>
<td>1987</td>
<td>0.00</td>
<td>2.16</td>
<td>2.38</td>
<td>0.22</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 3. Protein Supplementation with Cottonseed Meal

Steers Grazing Tobosa

<table>
<thead>
<tr>
<th>Profit/Day</th>
<th>*Crum protein below 7% in July</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.28</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Pitts et al., 1992: Journal Range Mgmt. 45:226-231.


Figure 3. Animal Performance & Stocking Rate

Upland Blue Grama Range in Colorado

This research was done with two-year-old cows in LA, OK, and SC, but the results are similar to those in other states. If in spite of your best efforts, cattle are thin at calving, opportunities may exist to “flush” British and Continental cross cattle with better quality pastures and/or supplements following peak lactation (around 60 to 70 days). This stage of lactation would accompany the forage “summer slump” time period for many Arizona ranching operations. If cattle have sufficient body fat reserves at calving they may safely coast through the summer slump and maintain acceptable conception rates. However, if cattle are below a body condition score of 4 at breeding time, it may be time to consider using a protein supplement if forage quality is low. Unfortunately, flushing thin cattle following peak lactation does not seem to work for Brahman cross cattle. Research in Australia has shown that lactating Brahman cattle often put the energy obtained from supplements into milk production instead of body fat (Hunter, 1991). This would suggest that the only opportunity one has for increasing fat stores for grazing Brahman cross cattle is before calving.

### How Much Supplement to Feed

The most cost effective method in feeding protein supplements is to supplement what is deficient in the forage (amount of protein required by animal - amount contained in forage). Guidelines for doing this are contained in University of Arizona Cooperative Extension Publication az9523 (Sprinkle, 2011). The maintenance requirements for a 1,000 lb. cow are listed in Table 5, but requirements will differ for different size cows and for different milk production. As an example in calculating the amount of protein to supplement, forage crude protein was tested and found to be 4%. For a 1,000 lb. nonlactating cow, the amount of protein that needs to be fed is 2.32 lbs. per day, which is calculated below.

1. Find the daily requirement for crude protein, which is 1.6 lbs.
2. Determine the amount contained in forage. If we estimate forage intake to increase to 1.7% of body weight for the supplemented cow, then crude protein in the forage is .68 lbs. (1,000 x .017 = 17 lbs; 17 x .04 crude protein in forage = .68 lbs. of protein)
3. Subtract the amount contained in forage from the daily requirement, which gives .92 lbs. of protein that need to be supplemented. (1.6 - .68 = .92 lbs. of protein needed)
4. Determine the amount of supplement to feed by dividing the amount of protein needed by the protein content of the supplement. If we feed cottonseed meal (44% crude protein), then 2.09 lbs. cottonseed meal would need to be fed on a dry matter basis (.92 lbs. protein ÷ .44 crude protein/lb csm = 2.09 lbs. cottonseed meal)
5. Because most protein supplements contain about 10% water, convert feed on a dry matter basis to an “as fed” basis. This would require the feeding of 2.32 lbs. of cottonseed meal per day to meet protein requirements. (2.09 ÷ .9 = 2.32 lbs. cottonseed meal)

The protein could be fed once a week (7 times the daily rate) without harming the cow (Huston et al., 1999). Ruminant animals have an ability to recycle some of the excess nitrogen contained in protein back to the rumen after it is consumed the first time

### Table 4. Pregnancy % by Body Condition Score

<table>
<thead>
<tr>
<th>Body Condition at Calving</th>
<th>Day 40 of Breeding Season</th>
<th>Day 60 of Breeding Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>43 ± 5</td>
<td>56 ± 5</td>
</tr>
<tr>
<td>5</td>
<td>65 ± 4</td>
<td>80 ± 4</td>
</tr>
<tr>
<td>6</td>
<td>90 ± 9</td>
<td>96 ± 8</td>
</tr>
</tbody>
</table>

Spitzer et al., May 1995. Journal of Animal Science

### Table 5. Maintenance Requirements of Range Cattle

<table>
<thead>
<tr>
<th></th>
<th>Energy</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TDN</td>
<td>% in diet or lbs.</td>
</tr>
<tr>
<td>Nonlactating, Mid-Pregnancy</td>
<td>9.1 lbs.</td>
<td>7.0 or 1.40</td>
</tr>
<tr>
<td>Nonlactating, Last Trimester</td>
<td>11.0 lbs.</td>
<td>7.9 or 1.60</td>
</tr>
<tr>
<td>Early Lactation, 18 lbs. milk</td>
<td>16.5 lbs.</td>
<td>11.0 or 2.24</td>
</tr>
<tr>
<td>Mid-Lactation, 10 lbs. milk</td>
<td>14.0 lbs.</td>
<td>9.6 or 2.00</td>
</tr>
<tr>
<td>Late Lactation, 7 lbs. milk</td>
<td>12.8 lbs.</td>
<td>9.5 or 1.90</td>
</tr>
</tbody>
</table>

(1000 lb. cow)
slowly than the urea molecule used in past formulations. This has
devised an urea molecule (biuret) that breaks down more
supplements to increase crude protein. Modern technology
and can decrease both forage intake and forage digestibility
supplements result in substitution of forage by the supplement
expected to perform as an energy supplement. Usually, energy
results to dry supplements. If the supplement does not contain
urea was 30%. If forage quality is very low and the supply of
performance when the percentage of crude protein derived from
below from research in Kansas represents a slight decrease in cow
It is important to know the ideal composition of protein
supplements to feed. Although we know very little concerning
the ideal amino acid profiles, research has identified the
advantage of using supplements with greater crude protein.
When five trials in Kansas were summarized, researchers found
that increasing crude protein of the supplement from 15 to 22 to
28% resulted in 49% greater forage intake and 22% greater forage
digestion (as cited by Paterson et al., 1996). Kansas researchers
also found that cattle fed a 13% crude protein supplement lost
193 lbs. over the winter and cattle fed a 39% crude protein ration
lost 97 lbs. over the winter (DelCurto et al., 1990).

In stressful situations in which cattle are losing weight, some
benefits have been demonstrated by feeding supplements
with approximately 40 to 60% of the protein being ruminally
undegradable or bypass protein. Feedstuffs high in bypass
protein include feather meal, corn gluten meal, and fish meal.
Due to palatability problems, rendered animal products are
usually limited to 25 to 30% of the total supplement and are
combined with grain products to increase palatability. Petersen
et al. (1996) reported that weight loss has been reduced and
conception rates increased in several experiments by feeding
bypass protein. However, they reported that bypass protein
supplementation only seems to be effective when animals are
losing weight. The additional cost per ton for adding bypass
protein is around $50 to $80.

When urea is substituted for natural protein in the supplement,
it is recommended that no more than 30% of the crude protein
in the supplement come from urea (Köster et al., 1996). The table
below from research in Kansas represents a slight decrease in cow
performance when the percentage of crude protein derived from
urea was 30%. If forage quality is very low and the supply of
forage limited (as in drought) avoid the feeding of any urea at all.

Liquid feed supplements can be expected to yield similar
results to dry supplements. If the supplement does not contain
sufficient protein (less than 22% crude protein) it can be
expected to perform as an energy supplement. Usually, energy
supplements result in substitution of forage by the supplement
and can decrease both forage intake and forage digestibility
(Caton and Dhuyvetter, 1997). Urea is often added to liquid
supplements to increase crude protein. Modern technology
has devised an urea molecule (biuret) that breaks down more
slowly than the urea molecule used in past formulations. This has

reduced the danger of urea toxicity for liquid feeds. Assumptions
made above for dry feeds on the percentage of urea included
in feeds and their effect upon performance are probably also
valid for liquid feeds. This is illustrated by the graph below.
Incremental increases in pregnancy rate were achieved by
increasing protein of the molasses supplement by urea and then
by cottonseed meal plus urea.

In a presentation given to the American Feed Industry
Association in 1995, J.E. Moore made the following conclusions
concerning the use of liquid feeds.

1. When forage quality was low, forage intake and average
daily gain (ADG) increased but ADG could still be low
or negative.
2. When forage quality was high, forage intake decreased,
but ADG increased if supplement contained meal + urea
or meal.
3. Forage intake decreased if forage intake was greater than
1.75% of body weight.
4. Forage intake increased if forage intake was less than
1.75% of body weight.
5. Forage intake decreased if supplement intake exceeded
.8% of body weight (about 8 lbs. for a 1000 lb. cow).
6. Forage intake increased when crude protein of the
supplement was greater than 22%.
7. Liquid feeds acted similarly to dry supplements for forage
intake.

Deciding Which Supplement to Use

What Kind of Protein Supplement to Use

The greatest benefits for protein supplements are usually
obtained with high protein of a natural origin (no protein from
urea). These type of supplements are also the most expensive
to use. A portion of the protein can be obtained from urea in
order to cheapen the protein supplement. Too much urea in
the supplement can result in reduced intake of the supplement
because of palatability problems or urea toxicity if cattle consume
too much of the supplement. Recommendations for urea
substitution of natural protein will be discussed later.

The way to evaluate protein supplement purchases is to
calculate the cost of each lb. of protein dispensed. This is
illustrated below for one supplement fed once a week at seven
times the daily rate vs. another supplement that is self fed.

Deciding Which Supplement to Buy

Supplement A: Fed once/wk (2 lbs./d x 7 = 14 lbs/ feeding)
Supplement B: Self fed (2.5 lbs / day)

1. Determine protein content of supplements:
   • Supp. A: 44% CP x 2000 lb. = 880 lb. protein
   • Supp. B: 36% CP x 2000 lb. = 720 lb. protein

2. Determine the cost/lb. protein:
   • Supp. A: $228/T or 228 ÷ 880 lb. = $ .26/lb. protein
   • Supp. B: $260/T or 260 ÷ 720 lb. = $.36/lb. protein

3. Determine the cost of dispensing supplements:
   • Supp. A: $70/T or 70 ÷ 880 = $.08/lb. protein
   • Supp. B: $20/T or 20 ÷ 720 = $.03/lb. protein

4. Determine protein each cow eats each day:
   • Supp. A: 2 lbs. x .44 = .88 lb. protein
   • Supp. B: 2.5 lbs. x .36 = .90 lb. protein

5. Determine the cost/cow / day:
   • Supp. A: .88 lbs. protein x (.26 + .08) = $.34/day
   • Supp. B: .90 lbs. protein x (.36 + .03) = $.35/day

6. Determine the cost for the herd:
   • Supp. A: $.34 x 60 d x 100 cows = $ 2040
   • Supp. B: $.35 x 60 d x 100 cows = $ 2100
Conclusions

1. The purpose of protein supplementation is to feed microbes so the cow can harvest more cheap forage.
2. Adequate available forage is required for protein supplementation to be effective.
3. Forage should be tested to determine if supplementation is needed.
4. Young cows respond more favorably to protein supplementation than do older cows.
5. If forage is less than 6.25% crude protein (CP), protein supplementation typically increases forage intake, decreases weight loss, and increases conception.
6. The optimum time to supplement is 60 to 90 d before calving.

Table 6. Substitution of Urea for Natural Protein

<table>
<thead>
<tr>
<th>Cows Grazing Winter Tallgrass Prairie</th>
<th>0% CP from Urea</th>
<th>15% CP from Urea</th>
<th>30% CP from Urea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplement Intake, lbs.</td>
<td>4.8</td>
<td>4.8</td>
<td>4.8</td>
</tr>
<tr>
<td>Wt. gain (28 Nov - 7 Feb)</td>
<td>48</td>
<td>42</td>
<td>14</td>
</tr>
<tr>
<td>Wt. gain (28 Nov - 21 Mar (Calving))</td>
<td>-37</td>
<td>-107</td>
<td>-130</td>
</tr>
<tr>
<td>Wt. gain (28 Nov - 27 Apr (Breeding))</td>
<td>-152</td>
<td>-152</td>
<td>-172</td>
</tr>
<tr>
<td>Wt. gain (28 Nov - 5 Oct (Weaning))</td>
<td>52</td>
<td>62</td>
<td>27</td>
</tr>
<tr>
<td>Pregnancy Rate, %</td>
<td>92.6</td>
<td>100</td>
<td>86.2</td>
</tr>
</tbody>
</table>

As a general rule, forage with 4% CP requires about 2 lbs. of cottonseed meal or soybean oil meal per cow per day.

To avoid hurting animal performance, keep CP supplemented by urea less than 30% of the total CP of the supplement.

Liquid feeds function much like dry protein supplements.

Literature Cited


