Phase-Feeding the Beef Herd for Improved Feed Utilization

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Introduction

Proper nutritional status is critical for optimal production efficiency in the beef cow herd. However, beef producers often take a "one size fits all" approach to feeding the cows in the cow herd. This singular approach to nutrient supply for the cow herd can have serious nutritional and economic ramifications. It should be obvious that not all cows have the same nutrient requirements. Nutritional requirements vary with age, breed, sex, body condition, environment, and physiologic status. By acknowledging differences in nutrient requirements that exist in the beef cow herd, management strategies can be implemented to feed beef herds to optimize feed resources and overall production.

The dairy industry utilizes the concept of differences in nutrient requirements of different cows within the herd and manages nutrient supply according. In that regard, the dairy industry approaches different cow nutrient requirements by implementing phase feeding in the cow herd. Phase feeding is defined as: changing the nutrient concentrations in a series of diets formulated to meet an animal's nutrient requirements more precisely at a particular stage of growth or production. Phase feeding in the dairy industry is implemented based on placing cows into multiple feeding groups based on their lactation status. The phase feeding strategy is utilized to address the different nutrient requirements associated with milk production intensity. The dairy industry addresses the nutrient requirements of cows not on a singular basis but on a multiple nutrient basis. These nutrients include net energy (NE), degradable intake protein (DIP), undegradable intake protein (UIP), crude protein (CP), fiber fractions and multiple minerals. By comparison, net energy of maintenance (NE_m) and metabolizable protein (MP), or TDN and CP nutrient evaluation may be sufficient as a starting point for the beef herd because the beef cows have lower production intensity compared to dairy cows.

Accurate supply of nutrients to cattle can have several positive outcomes. Providing the required nutrients can increase the production potential, reduce feed cost, and improve nutrient utilization thereby also reducing nutrient waste and decreasing environmental concerns. In some instances additional management input will be required, in others shifting management resources is all that is required. The cow herd's feed requirements amount to 54-75% of the annual maintenance costs for the

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herd (Houghton et al., 1990). Grazed forages comprise the largest and most important feedstuff for the cow. Utilization of forage through grazing is the most economical feed that is available to the cow herd. Grazed forages provide the majority of the nutrients for maintaining the cow during gestation, lactation, and breeding.

Differences in Beef Cattle Requirements

The mature, non-lactating beef cow in optimal body condition score (BCS) is the reference against which other cow requirements can be evaluated. Considerable variation is often found in the amount of nutrients and quality of feed required by the cow herd. The 1996 Beef Cattle NRC does an adequate job of predicting cow nutrient requirements (Table 1). Energy and protein requirements for the mature cow vary according to state of production. Even within the mature cow's production cycle there are easily identifiable periods of different nutrient requirements.

For demonstration purposes, I will utilize a cow that is 5 year-old, BCS 5, mature body weight (BW) 1,100 lb, peak milk production of 16 lb/d at 8.5 weeks after calving. The cow's nutrient requirements are only slightly above maintenance NE_m and MP requirements at seven months after calving, 8 mcal/d and 413 g/d, respectively; which amounts to about 49% TDN and 7% CP. The cow's requirements at this time are lower than at any other period in the annual production cycle. This time provides the cow-calf producer an opportunity to reduce feed costs by utilizing low quality feeds. At one month prior to calving, gestational requirements increase the cow's NE_m and MP requirements by 50 and 47%. The greatest percentage of growth of the fetal calf occurs during the final 3 months of gestation. Therefore, feed quality and quantity need to increase to meet the increasing nutritional requirements. At peak lactation, the mature cow's NE_m requirements are 20 and 80% greater and MP requirements are increased 29 and 89% compared to 1 and 6 months prior to calving. In comparison, a 3 yr-old cow one month prior to calving has a 54 and 48% increase in NE_m and MP requirements over her nutrient requirements at seven months before calving. Likewise, NE_m and MP requirements increase 11 and 20% from calving to peak lactation for 3 yr-old cows. Supplying sufficient quantity and quality of feed to meet the nutrient requirements of the pregnant heifer is especially critical. Two-year old and 1st calf replacement heifers have 52 and 46% increases in NE_m and MP from their lowest yearly requirement to just before calving. Interestingly, the percent change in NE_m requirement from 1 month prior to calving to peak lactation is zero. The NRC assumes that the NE_m requirement is already at its greatest level prior to calving due to requirements associated with maintenance, growth, and pregnancy. It appears that lactation only replaces the requirements associated with gestation. In reality this is not likely true when one considers that requirements increase during lactation for the mature cow. In contrast, MP requirements change from calving to peak lactation by 9%. This change is because of the same factors associated with the change in NE_m requirements. The change in MP requirements likely more accurately reflects the increase in requirements for the 1st calf heifer.

When comparing nutrient requirements of cattle at different ages, physiological factors must be considered. One such consideration is dry matter intake (DMI). If one assumes the example cow can consume 2% of its' BW in dry matter, DMI ranges from 22 lb/d for mature cows to 18 lb/d for 900 lb replacement heifers (Table 2). Therefore even though absolute amounts of NE_m and NP may not differ greatly, the concentration of NE_m and MP in diets needs to be different among ages of cattle to meet their requirements. Additionally, throughout the production cycle DMI capacity will vary. An additional complication occurs with the variation in DMI because of quality and quantity factors associated with forage based diets. The NE_m (mcal/d/lb DMI) and MP (g/d/lb DMI) requirements increase in all classes of cattle as they approach calving and at peak lactation. Thus, as cattle approach calving and lactation the concentration of energy and protein in their diet need to increase to meet requirements associated with maintenance, growth, gestation, and lactation. Prior to calving, NE_m requirements of 5 and 3-yr old cows are 15% greater than that of 2-yr old cows, which are 11% greater than replacement 1st calf heifers. A mature cow's MP requirements prior to calving are 12-14% lower than a 2-yr old cow's MP requirement, which are 12 to 9% lower than a 1st calf replacement heifer's.

Evidence exists for the importance of adequate cow body condition for return to estrus, improved pregnancy rate, and adequate weaning weights (Houghton et al., 1990; Sinclair et al., 1998; Wiltbank et al., 1962). Sufficient evidence in the literature recommends that cows be a minimum BCS of 5 on a 9 point scale at calving. The BCS 5 provides adequate body reserves of fat and protein for mobilization during early lactation. Moreover, mature cows that are thin prior to calving (BCS = 4) but on an increasing plane of nutrition can reap the same benefits; improved time to estrus, improved conception rates, and improved pregnancy rates, that mature cows in adequate BCS (≥ 5) exhibit. Additional research demonstrates that cows in adequate BCS are capable of withstanding stress associated with cold and wet weather better than thin cows. In addition, the cost associated with achieving adequate body condition are much cheaper to achieve during early and mid-gestation, when cow requirements are lowest compared with late gestation, lactation, and the breeding season. This becomes particularly important when one considers that 1 Mcal of body energy reserves is utilized at 80% of what dietary energy is utilized to supply maintenance energy. Figure 1 demonstrates the NRC (1996) determined energy required or supplied beyond the current dietary supply for a cow to move to different BCS. For a 1,100 lb cow to move from a BCS of 3 to a 5 requires an extra 387 Mcal above her NE_m requirements.

Relevant Research Results

The idea of phase feeding the beef cow herd may not have the prevalence that it does in the dairy industry, however there are specific research results that address many of the key issues of phase feeding. Numerous published research articles address the differences between gestation and lactation in cows, and differences between mature and young cows.

One criterion for separating the beef cow herd is body condition score. By assessing BCS producers can allocate cattle into nutritional feed groups (Tennant et al., 2002). Several reports have quantified the pounds of BW change required to change BCS. Body condition score at certain production milestones is important to predict cow reproductive performance and to help segregate cattle into feed groups. Tennent et al. (2002) examined over 14 years, the amount of BW required to change Angus cow BW to a BCS of 5 (9 point scale). For example, to move a BCS 4 cow to a BCS of 5 requires a 40, 46, 70, 37, 33, and 46 lb BW gain during the prepartum, postpartum, pre-breeding, post-breeding, mid-gestation periods, and overall, respectively. Whereas to move a BCS 3 cow to a BCS of 5 requires a 145, 141, 194, 119, 178, and 156 lb BW gain during the same time periods. Their conclusion was that BW changes required to alter BCS are not proportional across the starting BCS. Cows that have lower BCS (i.e. BCS 2-3) will require a greater BW gain to achieve a BCS of 5 compared to cows with a BCS closer to 5. Likewise cows with BCS much greater than 5 (i.e. BCS 7-8) can lose much more BW to achieve a BCS of 5 compared to cows with a BCS closer to 5. Additionally, the BW change needed to alter BCS is not consistent between periods of the yearly production cycle. These results indicate that to achieve a BCS of 5 additional management input will be required and not a "one size fits all" approach. By integrating observed BCS to BW gain, available ration balancing software can be utilized. In this way feed resources can be allocated on the basis of the BW gain required by each group of cattle.

One of the most likely ways to segregate the cow herd is by cow age. Differences in cow age are often translated into differences in cow BCS, DMI, milk production, reproductive performance, and ultimately nutrient requirements. Figure 2 is data complied by North Dakota State University in which they reported the cow age distribution within a herd over 20 years. Within this herd, 17% of the cows are in the 1st calf heifer category, whereas 11% of the herd is 10 years old or older. There are differences in the ability of cows to perform within similar nutritional environments. Sawyer et al. (2004) examined the ability of cull cows to perform in a finishing situation. Average daily gain, DMI, and gain efficiency decreased linearly with increasing cow age. Decreasing DMI and gain efficiency implies that additional feeding management would be required for cattle with advancing age because of a decreasing ability to compete for and utilize feed. It should be noted that crossbred especially *Bos indicus* x *Bos taurus* cattle have generally be recognized to have a longer productive lifespan compared to non-Brahman influenced cattle (Thrift and Thrift 2003).

Work by Sowell et al. (2003) reported the effect of cow age on forage and liquid supplement intake. Forage DMI increased from 26 lb/d by two year-old cows to 40 lb/d by five year-old cows. Likewise, supplement DMI increased from 1.1 to 1.5 lb/d as cow age increased. Bowan and Sowell (1997) reported variation in cow supplement intake regardless of supplement form or delivery method. The variation in intake of supplement stems from two likely sources, the opportunity to consume supplement in competitive situations and individual animal variation in intake in non-competitive situations. Sowell et al. (2003) monitored supplement intake distribution. The greatest range in supplement intake was reported for three and four yr old cows (Table 3).

Supplement intake variation was lowest (63%) for four year-old cows and greatest (98%) for five yr old cows. The targeted level of supplement intake was 1.1 lb of DM/d. Fifty-four percent of the two yr old cows consumed less than the targeted amount of supplement, whereas 42% of the 3-6 yr old cows consumed below the targeted supplement DMI. Total time of supplement consumption and feeding bouts per day were also lower for two and three year-old cows compared with older cows. Combined, these data indicate that the social interactions in a mixed age herd can result in lower supplement intakes by younger cows. Intake levels of supplements below that desired and formulated to meet cow nutrient requirements can have detrimental effects on young cow productivity. Management schemes that minimize the negative social interactions of boss cows on young growing cows would be advantageous.

Work by Johnson et al. (2003) examined forage intake of supplemented Brangus cows at three different time points. Regardless of period of production (late gestation, early lactation, and late lactation), multiparous cows had greater DM and total digestible organic matter intakes compared to primiparous cows (Table 4). During early and late lactation the efficiency of converting dietary energy to milk production was over 40% greater for multiparous than primiparous cows (Johnson et al., 2003). These authors stated that potential differences in milk production efficiency could include energy utilization for growth by primiparous cows, potential differences in mobilization of body fat, milk composition, and/or maintenance energy requirements. Forage intake of all cows increased by 44 and 22% during early and late lactation compared to late gestation, however these cows decreased consumption by 18% from early to late lactation (Johnson et al., 2003).

In a comparison of the utilization of low and high quality forage by heifers and mature cows, Varel and Kreikemeier (1999) indicated that mature cows are able to utilize low-quality forages better than young heifers. Mature cows consumed 27 and 50% more organic matter, had greater ruminal organic matter fill, and lower fluid fill than heifers. The mature cow's ability to utilize both low and high-quality forages better than heifers may be attributed to greater ruminal OM digestion, thereby likely providing a greater dietary energy supply and flow of nitrogen to the duodenum.

Dividing the Cow Herd

There are several factors to consider before splitting up the cow herd to phase feed the herd as an alternative to whole-herd management. The first consideration is total cow herd size. Phase-feeding management will likely work best in herds of 100 cows or more, splitting a herd with less than 40 head will not be effective in terms of labor and equipment use (Blasi, 1995). Splitting the cow herd also requires multiple pastures, fencing, water, and likely feeding facilities (troughs, lick tanks, hay rings, etc.). In the nominal beef herd some easily identifiable groups exist they are: 1) dry, mature pregnant cows, 2) lactating mature cows, 3) pregnant replacement heifers, 4) weaned replacement heifers, 5) growing steers and heifers, 6) herd bulls (Gadberry, 2003). In addition, special groups of cattle such as thin cows and lactating 1st calf heifers have additional nutritional and management requirements.

Not all of the previously listed five groups will exist in every herd or it may not be feasible to split the herd into that many groups. However, generally at least three groups can be made from a typical cow herd. Separation into three manageable groups will assist in matching the nutritional needs of each group.

Group 1 – Mature cows in good BCS. These cows will have lowest maintenance requirements. Mature cows can utilize low-quality forages and will likely require less supplementation. Herd bulls would fall in this group, but they should be managed as a separate group to maintain a defined breeding season.

Group 2 – Bred replacement heifers and 2nd calf cows. As mentioned previously, these cows are young, still growing, and do not compete effectively for feed with mature cows. Likely, better quality forages and supplemental feeds will be required by this group to meet growth, gestation, and lactation requirements.

Group 3 – Thin and old cows. This group should include cows older than 10 years old or with a BCS less than four. As noted earlier Brahman cross cattle may be older before entering this group. These cows will need extra energy during several periods of the production cycle. This group should be the most fluid group, because as cows gain BCS or are culled because of age, cows will move out of the group.

Another additional consideration for dividing the cow herd besides age and BCS is expected calving date. As calving date approaches cow requirements increase, thus additional nutrition may be needed. Separating by calving date also provides some management advantages concerning calving management. As a practical point, weaning a calf is often easiest way to manipulate a post-partum cow's nutritional requirements. The creation of different groups allows each group to utilize the variation in quality and quantity of feedstuffs to optimize the use of feed resources. A much more efficient and economical job can be done if the cattle are separated into feeding groups to address their nutritional requirements.

Practical Application in the Beef Herd

In order to gain the advantage that separate group or phase feeding the cow herd allows, a producer needs to match the requirements of the cows to the feedstuffs available. In a large cow herd with a wide range of individual nutrient requirements there are three basic feeding options. The feeding options are: 1) feed all cows in the herd to the requirements of the highest in the group, in which case many cows will be overfed and feed resources wasted, 2) feed to the lowest requirements in the group, in which many cows will be underfed and production will suffer, 3) feed to the average of the group requirements and a bit of all of the above will occur. The key is to allocate cows to groups so that individual cow requirements are as close as possible.

The nutritional requirements of the dry, mature, pregnant cow are only slightly above maintenance and lower compared to any time period during the production cycle.

Cow nutrient requirements increase dramatically after calving and during lactation especially leading up to peak milk production and the rebreeding period. Milk production has a close positive relationship to nutrient requirements. Therefore, during this period feed quality and quantity should be increased. The pregnant replacement heifer is an interesting mix; on one hand she still has nutrient requirements for both growth and pregnancy, on the other hand she is growing and her intake potential has increased so that some lower quality feed can be utilized. Additionally, as mentioned before the replacement heifer after she calves has maintenance, growth, and lactation nutrient requirements. Weaned replacement heifers have the disadvantage of having the greatest requirements for growth while being at the bottom of the social food chain. Thus if weaned replacement heifers are fed with the mature cow herd, these heifers are likely to under consume supplemental feeds resulting in inadequate nutrient supplies to meet growth requirements in order to reach adequate BW for future breeding. In addition, because cows derive more total energy from their ruminal fermentation and have lower maintenance energy requirements than heifers, higher-quality diets will be required for heifers than for cows to achieve acceptable performance (Varel and Kreikemeier, 1999). In situations in which producers are retaining ownership to increase sale weights growing cattle should be fed separately. Because these calves have limited DMI ability, relative to more mature and larger cows, more nutrient dense feedstuffs need to be utilized. Growing cattle most likely will need grain and protein supplementation, which more mature cows do not need, to achieve production goals. Another consideration for pregnant replacement heifers, weaned replacement heifers, and growing animals is the source of supplemental protein. Mature cows can utilize non-protein nitrogen well, whereas the growing animals utilize and perform better consuming natural protein sources. Herd bulls will be the smallest group. Depending on the bulls' condition maintenance feeding is all that is required; therefore bulls can utilize low-quality forages and non-protein nitrogen.

A practical example of the advantage of phase feeding the cow herd occurs when feeding cows of different BCS. In order to move a 1,100 lb Brangus cow from a 3 to 4 BCS, 83, 48, or 42 lbs of bahiagrass hay, molasses, or soybean hulls would be required above the feed for maintenance. Similarly to move a cow from 4 to 5 BC requires an additional 94, 55, or 48 lbs of bahiagrass hay, molasses, or soybean hulls, respectively. In contrast, a cow with a BCS of 6 could be allowed to move to a 5 BCS and 75, 44, or 39 lbs of bahiagrass hay, molasses, or soybean hulls could be saved. In this scenario, if cows of BCS 3 and/or 4 are in the same group as BCS 6 cows, the dilemma becomes what group of cows you are feeding to meet requirements.

Decisions regarding feed resources should be made to optimally match animal requirements and nutrients supplied by the feeds. In that regard cows with greater requirements should be supplied with the highest quality feeds. Because beef cattle production does rely on pasture based production for the majority of feed resources cattle producers can utilize this to some advantage. Grazing management systems that allow different groups of cattle to utilize the same forage but at different times and quality is an option. Grazing systems like lead-follow, 1^{st}-2^{nd}-3^{rd} grazers work to allow cattle in groups with greater requirements to have first access to the pasture forage and can thereby select the forage with the greatest nutritional value.

A main consideration between the dairy industry and beef industry implementation of phase feeding is the source of the feed. In the dairy industry during much if not all of the production cycle the dairyman provides the feedstuff to the dairy cow. The herd's nutrition and defined groups' nutritional supply can be more tightly controlled and matched to the cows' requirements. Feed inputs, production output, and efficiency of use can be measured in relative ease. However in the beef industry, pasture based production system for the cow herd is the predominate production practice. Utilization of pasture and forage feedstuffs introduces unknowns in terms of nutrients supplied, consumed, and utilized. Pasture production systems also offer challenges due to seasonal variation associated with the nutrient supply.

Conclusion

There are many pasture-roughage-supplement feed options that are typically available. Understanding the nutritional needs of the individuals within the cow herd can help to allocate feed resources. Rather than taking the "one size fits all" management practices, phase feeding can prevent over-and underfeeding of the cow herd and thus giving cattle producers more flexibility to utilize feed resources and obtain a greater return on investment of feed resources. Optimal investment of the feed resources into the cow herd can positively influence the cow's performance. Increased cow performance through improved nutrition will result in improved economic efficiency for the beef cow enterprise.

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Table 1. Daily net energy of maintenance (NE_m) and metabolizable protein (MP) requirements of cows with different age during the production cycle

Cow		Months since calving											
Age	BW, lb	1	2	3	4	5	6	7	8	9	10	11	12
		NE_m, Mcal/d											
5	1,100	13.6	14.5	14.0	13.0	12.1	11.4	8.0	8.2	8.7	9.4	10.5	12.1
3	1,100	12.9	13.7	13.3	12.5	11.7	11.1	8.0	8.3	8.8	9.5	10.7	12.3
2	1,000	12.2	12.9	12.6	12.1	11.5	11.0	8.4	8.7	9.2	10.0	11.2	12.8
Heifer	900				7.6	7.8	8.0	8.4	8.8	9.3	10.1	11.3	12.8
		MP, g/d											
5	1,100	718	781	744	676	609	555	413	423	442	473	525	606
3	1,100	673	730	698	639	582	535	412	424	443	476	528	610
2	1,000	626	676	651	604	558	521	420	434	455	489	543	627
Heifer	900				393	403	413	425	441	462	493	541	614

Table 2. Net energy of maintenance (NE_m) and metabolizable protein (MP) requirements per pound of dry matter intake of cows with different age during the production cycle

Cow	DMI	Months since calving											
age	lb	1	2	3	4	5	6	7	8	9	10	11	12
		NE_m, Mcal/lb of DMI											
5	22	0.62	0.66	0.64	0.59	0.55	0.52	0.36	0.37	0.40	0.43	0.48	0.55
3	22	0.59	0.62	0.61	0.57	0.53	0.51	0.36	0.38	0.40	0.43	0.49	0.56
2	20	0.61	0.65	0.63	0.61	0.58	0.55	0.42	0.44	0.46	0.50	0.56	0.64
Heifer	18				0.42	0.43	0.44	0.47	0.49	0.52	0.56	0.63	0.71
		MP, g/lb of DMI											
5	22	32.6	35.5	33.8	30.7	27.7	25.2	18.8	19.2	20.1	21.5	23.9	27.6
3	22	30.6	33.2	31.7	29.1	26.5	24.3	18.7	19.3	20.1	21.6	24.0	27.7
2	20	31.3	33.8	32.6	30.2	27.9	26.1	21.0	21.7	22.8	24.5	27.2	31.4
Heifer	18				21.8	22.4	22.9	23.6	24.5	25.7	27.4	30.1	34.1

Table 3. Effect of cow age on performance and forage and supplement consumption

	Cow age, yr						
Item	2	3	4	5	6	SEM	*P*-value
BW change, lb	-46[a]	-62[b]	-73[b]	-73[b]	-62[b]	7.0	0.01
BCS change	-0.4	-0.4	-0.4	-0.4	-0.4	0.008	0.88
Forage DMI, lb/d	26[a]	32[b]	35[c]	40[d]	36[c]	1.2	0.001
Supplement DMI, lb/d	1.1	1.8	2.0	1.5	2.4	0.29	0.002
Supplement DMI range, lb	0 – 5.1	0 – 10.3	0 – 9.0	0 – 6.4	0 – 5.9	-	-
Proportion of cows with supplement DMI below target, %	54.4	43.2	37.2	46.3	18.8	9.4	0.12

[a,b,c,d] Means within a row with different superscripts differ $P < 0.05$.
Adapted from Sowell et al., 2003.

Table 4. Effect of cow age (multiparous or primiparous) and genetic potential for milk production (high or low) on forage intake during different periods

	High MEPD[a]		Low MEPD			*P*-value	
Item	Multi.	Primi.	Multi	Primi.	SEM	Age	MEPD
Gestation							
Forage DMI, lb/d	22.2	17.8	22.7	18.5	1.5	0.01	0.73
Early lactation							
Milk yld, lb/100 lb BW	10.1	8.4	9.0	5.9	1.0	0.02	0.09
Forage DMI, lb/d	30.4	26.4	29.0	23.3	0.8	0.001	0.01
Milk Production Efficiency[b]	1.74	1.12	1.79	0.94	0.19	0.01	0.75
Late lactation							
Milk yld, lb/100 lb BW	7.9	5.5	7.7	4.4	0.9	0.001	0.36
Forage DMI, lb/d	25.7	23.8	26.4	20.7	1.0	0.01	0.23
Milk Production Efficiency	1.68	0.97	1.87	1.02	0.22	0.001	0.51

[a]Milk EPD of cow's sire
[b]Mcal of NE_m used for milk / Mcal of NE_m available for production
Adapted from Johnson et al. 2003.

Figure 1. Energy required for cows with different body weight to increase condition score

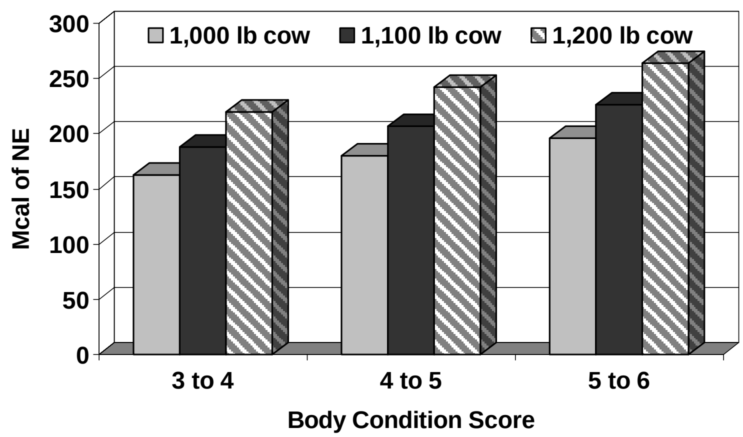

Figure 2. Cow age distribution in a herd