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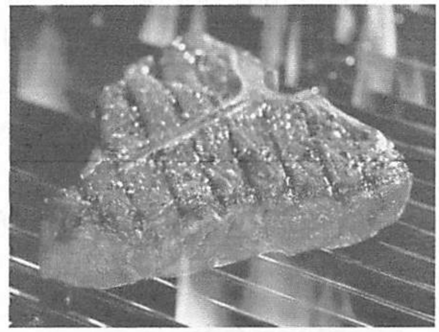

Beef – Good and Good for You

Rick Machen and Chris Kerth
2013 TAMU Grassfed Beef Conference

Relative to foods, eating habits and US consumer preferences, the spectrum is perhaps broader today than it has ever been. And to meet this array of preferences, the beef industry must offer traditional, natural, grassfed and organically produced products.
Beef is a nutrient dense source of protein, essential vitamins and minerals. Though recognized as a low-calorie protein source, beef also contains fat, a dense source of energy that fuels the body.

Beef – 3 Primary Components

Raw beef consists primarily of water, protein and lipids (fat), with water being the largest of the three components. Fat is deposited subcutaneously, abdominally, between muscles and within muscles. Fat content of beef is primarily a function of dietary energy density and days on feed/forage. The fat content of whole muscle beef servings is influenced by primal cut origin (chuck, rib, loin or round), level of trim and in the case of ground product, the intentional level of fat inclusion.

PUFAs

Lipids (fats) are found in both plant and animal tissues. Per unit, fats contain 225% more energy than carbohydrates and both provide 'energy' to fuel body functions. At the cellular level, glucose is the primary carbohydrate fuel whereas fatty acids are the primary fuel from fats. Fatty acids contain carbon (6 to 28 atoms), hydrogen and oxygen.

Fatty acids can be separated into two groups – saturated and unsaturated.
Unsaturated fatty acids contain carbon atoms that are 'double bonded' to other carbon atoms; saturated fatty acids have no double bonded carbons. Within the unsaturated fatty acids, those with more than one double bonded carbon group are known as

polyunsaturated fatty acids (PUFAs). The PUFA content of several food ingredients is shown in Table 1. These food sources were chosen to demonstrate the fact that some nuts, seeds and oils are high in PUFA content while meats and dairy products have a much lower PUFA content.

PUFAs may not be equal when it comes to their contribution to health and wellness. Epidemiological, biomedical and nutritional research results published in peer-reviewed journals are inconclusive. Some suggest a benefit (especially for those at risk for and those experiencing coronary heart disease) associated with increasing the dietary level of omega-3 fatty acids. The omega-3 fatty acids are in the essential fatty acid group, meaning the human body cannot make them. The omega-3s of primary interest are alpha-linolenic acid (ALA; found primarily in walnuts, flaxseeds, canola and soybean oils) and two others abbreviated as EPA and DHA (eicospaentaenoic acid and docosahexaenoic acid, respectively). The most concentrated sources of EPA and DHA are fatty fish such as salmon, tuna, mackerel or sardines. The American Heart Association currently recommends eating this type of fish at least twice a week.

Table 1. Food sources of PUFAs*

	PUFA g/100 g fat
Cooking Oils	
Corn Oil	59
Shortening	26
Olive Oil	15
Butter	4
Nuts and Seeds	
Sunflower Seeds	66
Flaxseeds	65
Walnuts, dry roasted	63
Peanuts, dry roasted	31
Meats	
Chicken breast	21
Salmon	28
Pork Chop	8
Beef	5
Dairy Products	
Milk, whole	4
Cheese	3
Ice Cream, gourmet	4

*National Nutrient Database for Standard Reference, USDA ARS www.ndb.nal.usda.gov

The omega-3 content of selected foods and oils is shown in Table 2. Of particular interest is the magnitude of difference in omega-3 fatty acid content between the foods. *Considering the current American Heart Association recommended daily intake of one gram of omega-3 fatty acids, it quickly becomes apparent that beef, regardless of production system, is not a reasonable source of omega-3s.*

Traditional versus Grassfed Beef

Grassfed beef is frequently advertised and promoted as having a higher omega-3 fatty acid content than traditionally produced beef. The data from Auburn University presented in Table 3 supports this claim. In this dissertation project, fall-born crossbred steers were finished on ryegrass, fed varying levels of corn on pasture or fed a grain-based balanced ration in a feedyard.

Table 2. Omega-3 Fatty Acid Content of Various Foods*	
	Ω-3, g/4 oz. portion
Walnuts, English	10.4
Flaxseed	7.2
Salmon, Atlantic, fresh	1.7
Beef, grassfed**	0.04
Beef, traditional**	0.01
American Heart Association Recommendation, g Ω-3/day	1.0

*from Minnesota Nutrient Data Base 4.04, Tufts University School of Medicine, Boston, MA.
**from C.W. Rowe. 2010. Carcass, Sensory, Quality and Instrumental Color Characteristics of Serially Harvested Forage-Fed Beef. Dissertation, Auburn University, p.90.

Table 3. Least square means for longissimus muscle Omega-3 fatty acid composition (mg/4 oz. raw) from steers finished on ryegrass with various levels of supplementation or ad-libitum mixed ration grain diet.*

	grain fed, percent of body weight					
	0	0.5%	1.0%	1.5%	2.0%	Feedlot
Omega-3	112[a]	66[b]	68[b]	34[b]	66[b]	30[b]
Daily consumption to achieve AHA recommendation	35 oz.	61 oz.	59 oz.	118 oz.	61 oz.	133 oz.

[a,b] Means with different letters differ statistically (P<0.05.
*from K.W. Braden. 2006. Alternative Beef Finishing Strategies: Effects on Animal Performance, Retail Shelf Life, Sensory, Fatty Acid Profile and Lipid Stability. Dissertation. Auburn University, p. 67.

As reflected in Table 3, longissimus muscle from grass finished steers had a significantly higher (P<.05) omega-3 fatty acid content. Perhaps of greater significance are the calculations showing the daily beef consumption required to meet the current American

Heart Association (AHA) recommendations (assuming beef is the only source of omega-3 fatty acids in the diet).

According to USDA data, per capita beef consumption in the US is currently less than 3 ounces per day. Therefore, it is highly unlikely any consumer will meet the AHA recommended daily intake of omega-3 fatty acids through beef consumption alone.

Summary

Beef producers and consumers alike should exercise caution when interpreting data. Statistical significance is not necessarily paralleled by biological importance. As demonstrated in the literature and highlighted herein, grassfed beef is statistically proven to contain a greater amount of the beneficial omega-3 fatty acids. However, when compared to the current AHA recommendation for omega-3 intake, beef alone is an insufficient source of these fatty acids thought to be beneficial for heart health.

Natural, Grass-Fed and Organic Beef

Rick Machen, PhD
2010 TAMU Beef Cattle Short Course

Health consciousness is an ever increasing concern – in the political, environmental, social and personal health arenas. As Americans attempt to eat healthier food, producers respond and new products appear in the marketplace - and beef is no exception. As "natural", "grass-fed" and "organic" beef become more visible in meat markets, on menus, and in the media, producers and consumers alike have questions relative to production specifications, market potential and nutrient content.

Many of these new beef products claim nutritional or wholesomeness superiority over conventionally produced beef. Science-based, peer-reviewed nutrition research reviews do not support such claims. Natural, grass-fed and organic beef refer to production systems that yield beef products which are similar in nutrient content, safety and wholesomeness to conventionally produced beef. Supporting evidence in the scientific literature includes:

"No evidence of a difference in content of nutrients and other substances between organically and conventionally produced crops and livestock products was detected for the majority of nutrients assessed in this review suggesting that organically and conventionally produced crops and livestock products are broadly comparable in their nutrient content."[1]

"A recent systematic review of peer reviewed evidence published in the past 50 years concluded that organically and conventionally produced foodstuffs are broadly comparable in their nutrient content."[2]

A team of Texas AgriLife researchers recently reported that "contrary to popular perception, ground beef from pasture-fed cattle had no beneficial effects on plasma lipid."[3]

Results of a Texas Tech/USDA study found "no difference in cholesterol content between grass-fed and conventionally produced steaks."[4] When finished to the same degree of fatness, nutrient content of beef products is very similar across the different production systems.

Without question, food produced by American ranchers and farmers is safe and wholesome – perhaps the best in the world. As evidence thereof, consider these economic figures:

"American consumers enjoy the safest, most abundant, and most affordable food supply in the world at less than 11 percent of income."[5]

"Food *affordability*, the combination of food cost *and* consumer purchasing power, rather than just the absolute cost of food, is perhaps the most meaningful criteria by which to evaluate or compare food costs. USDA-ERS data shows a declining trend in food expenditures, from 22.7% of annual disposable money income in 1929 to 11.8% in 2009."[6]

The intent of this paper is to help beef producers and consumers better understand the basic similarities and differences between conventional, natural, grass-fed and organic beef production systems (see Table 1).

Conventional

Over 90% of domestically produced beef comes from conventional production systems – cows consuming primarily forages, their calves grazing alongside until weaning at 5-8 months of age. Upon weaning, beef calves typically:

- are pastured as stocker cattle in a grazing system, then moved to a feedyard for finishing as described below or.
- are moved directly to a feedyard for finishing on a complete, balanced, high concentrate diet.

Health Management – Primary focus is on preventative health care including vaccinations, and biosecurity measures.

- Antibiotic use is primarily therapeutic.
- An ionophore may be fed to improve feed efficiency.
- Growth promoting implants may be used to enhance weight gain.

Marketing – Auction markets remain the primary avenue for marketing feeder calves and market cows and bulls[7,8,9]. Other options include direct sale, video or internet offerings and retained ownership.

Natural, grass-fed and organic are pre-harvest beef production systems.

Natural

Many foods are described as being "natural". To use the term "natural'" on a food label, USDA requires adherence to only three specifications, all of which pertain to the post mortem handling/processing of beef. The USDA specifications are product:

1) must be minimally processed;
2) cannot contain any artificial ingredients and,
3) cannot contain any preservatives.

By this definition, most fresh, conventionally produced beef qualifies as natural. In the retail case, this definition applies to beef that does not have an ingredient label (products with marinade, tenderizer or other additives require a label). If there is no ingredient label, it is assumed the product is natural.

However, most branded beef programs have additional requirements for their specific "natural" beef products. At the present time, there are over 30 companies that purchase cattle and/or beef that qualifies as natural[6].

Health Management – Primary focus is on preventative health care including vaccinations, and biosecurity measures. Natural beef programs may have a variety of brand-specific specifications. Some examples include:

a) no antibiotic use (known as "never ever" programs)
b) limited antibiotic use (known as "not lately" programs; most programs prohibit antibiotic use within the last 100 days prior to harvest.)
c) ionophore use may (or may not) be allowed
d) use of growth promoting implants is generally not allowed
e) use of feed containing mammalian protein or fat may be restricted

Marketing – To qualify for a natural branded program, some level of source and management verification is required. Consequently, most calves that qualify for natural beef programs are sold:

- as feeder, stocker or fed cattle through an alliance with one of the natural branded beef programs or
- direct from producer to a packer, retailer or consumer.

Adherence to the requirements of a branded natural beef program is overseen and enforced by the branding company's management or a representative thereof.

Grass Fed

Grass-fed beef has at least three definitions.

According to USDA the term 'grass fed' applies to "ruminant animals and the meat and meat products derived from such animals whose diet, throughout their lifespan, with the exception of milk (or milk replacer) consumed prior to weaning, is solely derived from forage which, for the purpose of this claim, is any edible herbaceous plant material that can be grazed or harvested for feeding, with the exception of grain.

Animals cannot be fed grain or grain products and must have continuous access to pasture during the growing season.

Hay, haylage, baleage, silage, crop residue without grain, and other roughage sources may also be included as acceptable feed sources. Consumption of seeds naturally attached to forage is acceptable. However, crops normally harvested for grain (including but not limited to corn, soybean, rice, wheat and oats) are only eligible if they are foraged or harvested in the vegetative state (pre-grain).

Routine vitamin and mineral supplementation may also be included in the feeding regimen. If incidental supplementation occurs due to inadvertent exposure to non-forage feedstuffs or to ensure the animal's well being at all times during adverse environmental or physical conditions, the producer must fully document the supplementation that occurs including the amount, frequency and the supplements provided."[10]

The American Grass-fed Association (AGA) further defines their products:

a) Animals having been, from birth to harvest, fed on grass, legumes and forages and,
b) Animals having not been: creep fed as calves, fed for extended periods in confinement, or finished on grains.

AGA further defines beef products according to a three tier system. AGA Grassfed and Pasture Finished cattle "must be maintained at all times on range, pasture or in paddocks with at least 75% forage cover or unbroken ground for their entire lives." Further, such cattle "cannot be fed stockpiled forages in confinement for more than 30 days per calendar year."

Tier 1 – animals must be maintained on 100% forage diets with no exposure to any non-forage supplements.

Tier 2 – animals may only be fed approved non-forage supplements to ensure the animal's well being during periods of low forage quality or inclement weather.

Tier 3 – Pasture finished cattle may be fed approved non-forage supplements at a rate of 0.5% of body weight during the growth stage and 1.0% of body weight (DM basis) during the finishing phase. Here, finishing is defined as the last 200 pounds gained before harvest.[10]

The National Cattleman's Beef Association defines grass-finished beef as "that produced from cattle that grazed pastures their entire lives."

<u>Health Management</u> - Primary focus is on preventative health care including vaccinations and biosecurity measures. Most grass-fed programs specify:

- no therapeutic or sub-therapeutic antibiotic use (a "never ever" program)
- no growth promoting implants
- no ionophores

Cattle that are injured or become ill typically receive therapeutic [antibiotic] treatment and are marketed as conventionally produced beef.

From an animal well-being standpoint it is critical that cattle (in these non-conventional production systems) which become ill, injured or burdened with internal and/or external parasites be treated in a timely manner and with the most effective product, regardless of whether or not the treatment will prevent them from being retained in these branded programs.

Marketing – Forage-fed cattle grow slower than similar cattle in a conventional system. Consequently, most grass-fed cattle are harvested at an older age and a lower weight than those in a conventional or natural production system.

Compared to conventional, marketing natural, grass-fed and organic beef is more intensive and more involved.

Carcass fat will likely not be bleached white in color. Depending on the quality and type of forage grazed during the 120 days immediately preceding harvest, carcass fat may be from pearl white to yellow (beta carotene from green forages is stored in fat tissue).

Whole muscle cut size and dimension may be different than conventional or natural beef, due primarily to the lower harvest weights.

Note: In contrast to conventional and natural beef, grass-fed beef is also imported from other countries. Seldom can U.S. grass-fed product compete with imports on a cost per pound basis. Exporting countries (ex. Uruguay) have a lower cost of production due to lower land, labor and other input costs.

Marketing – To qualify for a grass-fed branded program, source and management verification is required. Consequently, most cattle that qualify as grass-fed beef are sold direct from the producer to a:

- packer
- wholesaler
- retailer or
- consumer.

Compliance with the requirements of a grass-fed beef program are often monitored by on farm/ranch visits and audits performed by the affiliated marketing alliance or a certifying agency.

Organic

Organic beef production and marketing is defined by USDA standards developed for all food labeled as "organic".[12]

Organic beef production requires more time, effort and documentation than the other production systems described herein. Livestock production and handling standards, outlined in USDA's National Organic Program (NOP)[12] include:

* Animals for slaughter must be raised under USDA certified organic management from the last third of gestation to harvest.
* Diets must contain feedstuffs that are certifiably 100% organic.
  Forages, cereal grains and oilseeds (ex. cotton, canola, soybean) must be grown without the use of synthetic fertilizers, herbicides or pesticides. Initially, organic crop production is preceded by a three year period of abstaining from the use of "prohibited substances" (for a list see National Organic Program standards).
  Preference will be given to the use of organic seeds and planting stocks. Nonorganic seeds/stock may be used in specific instances and with NOP approval.
  Use of genetically modified (GMO) crops is prohibited.
* Dietary vitamin and mineral supplements are allowed as warranted.
* Use of growth promotants or antibiotics (for any reason) is strictly prohibited.
* Organically produced cattle must have access to the outdoors, including access to pasture. Daily intake requirements call for a minimum of 30% of their daily intake come from standing forages during the growing season. Temporary confinement is allowed for reasons of health, safety, stage of production or to protect soil or water quality.
* Animals must be processed and handled under USDA certification.

Health Management - Primary focus is on preventative health care including vaccinations, and biosecurity measures. According to NOP standards, producers must not withhold treatment from a sick or injured animal; however, animals treated with a prohibited medication may not be sold as organic. Upon recovery, treated cattle are marketed as conventionally produced beef.
Although not specifically addressed in the NOP standards, concerns over animal welfare issues are growing due to inadequate control of internal and particularly external parasites in some organic production system.

Marketing – As mentioned above, cattle must be processed and handled under USDA certification, *from the last third of gestation to consumer purchase*. Consequently, organic beef moves from farm or ranch of origin through a well defined, traceable, certifiable processing, handling and marketing chain.

"Organic" requires USDA certification, involves audits and requires more time, effort and documentation than other beef production systems.

Within Texas, the USDA's National Organic Program (NOP) is managed and audited by the Texas Department of Agriculture, Organic Certification Program.[13]

Economics

It is beyond the scope of this paper to include a detailed economic analysis of the four beef production systems discussed herein. Production goals and costs are unique to each operation, so comparisons between operations or across production systems are difficult without some type of standardization. However, the following generalizations seem accurate:

- Conventional (C) beef production is likely the most efficient, lowest total cost of production system.

- By definition, natural (N) beef production is very similar (and in many cases identical) to conventional production. Brand specifications (such as no ionophore, no growth promotants) often result in some loss of efficiency and/or increase in cost of production. Differentiation from conventional beef production in promotion and the marketplace represents some amount of additional expense to the system.

- Slower growth rates and lower harvest weights associated with grass-fed (GF) production result in less production efficiency and greater production cost (compared to C and N) per unit of product. Total system pasture cost is inherently greater since cattle (stocker and finishing cattle) are grazed for much longer periods of time compared to C and N systems.
  Differentiation from other production systems in promotion and the marketplace is an additional expense to the system.

- Availability and cost of organically certified forages and feedstuffs is a significant concern for Texas producers considering organic (O) production. Precluding the prudent and environmentally sound use of technology such as synthetic fertilizers, herbicides, pesticides, growth promotants and pharmaceuticals results in an increased cost of production (ex. lower production per unit of input, increased labor cost) for organic beef.
  Differentiation from other production systems product in promotion and the marketplace is an additional expense to the system.
  The documentation required for O food production, preparation for audits and compliance with the processing and handling requirements all represent additional cost for an O production system.

Beef producers considering a different production system should carefully consider the options and their respective requirements. Like breeds of cattle, it is not (and need not) be "one kind fits all" when it comes to producing beef.

Summary

The current trend in consumer preferences indicates continued growth in demand for natural, grass-fed and organic beef products; no doubt, the availability of such products has resulted in the retention of beef consumers that would otherwise have abandoned beef as their source of animal protein. Long-term success of the U.S. beef industry depends on customers repeatedly voting on beef with their food dollars.

However, promotion of any one product at the expense of beef from the other production systems is <u>not</u> in the best interest of the U.S. beef industry.

Promotion of any one product, at the expense of beef from other production systems, is not in the best interest of the U.S. beef industry.

Quoting from an article entitled "*Brown eggs, grain and truth in marketing*" by John Maday[14],

> "*If consumers want brown eggs, sell them brown eggs. But market them as brown eggs, not anti-white eggs.*"

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Table 1. U.S. Beef Production Systems

System	Description		
	Preweaning	Postweaning	Finishing
Conventional	Cows and calves subsist primarily on forages – either by grazing or consuming harvested forage such as hay or silage. Supplements of plant origin are provided during times of [forage] nutrient deficiency.	Calves may continue a grazing program until forage or market conditions and/or production objectives dictate a move to the feedyard. Otherwise, calves move directly from their farm/ranch of origin to a cattle feedyard.	Cattle are fed a complete balanced grain-based diet until reaching the desired harvest endpoint (weight and/or degree of fatness).
	*USDA specifications**		
Natural	Same as conventional	Same as conventional	Same as conventional
	Natural involves post-harvest handling and refers to a product that contains no artificial ingredients or added color and is only minimally processed (processes limited to those that do not alter the raw product).		
Grass Fed	Supplementation is limited to times of adverse environmental or physical conditions. Amount, frequency and type of supplement provided must be documented by producer.	Supplementation is limited to times of adverse environmental or physical conditions. Amount, frequency and type of supplement provided must be documented by producer.	Cattle are fed to harvest endpoint on any edible herbaceous plant material that can be grazed or harvested for feeding, with the exception of grain. Consumption of cereal grains (corn, wheat, oats, barley) or grain sorghum is prohibited.
Organic	Forages and supplements must be organically produced (and handled where applicable).	Forages and supplements must be organically produced (and handled where applicable).	All ingredients in the finishing diet must be organically produced (and handled where applicable).

*In addition to USDA specifications, natural, grass-fed and organic programs may restrict or prohibit certain animal, forage, health and nutrition management options that are approved for use in conventional production systems.

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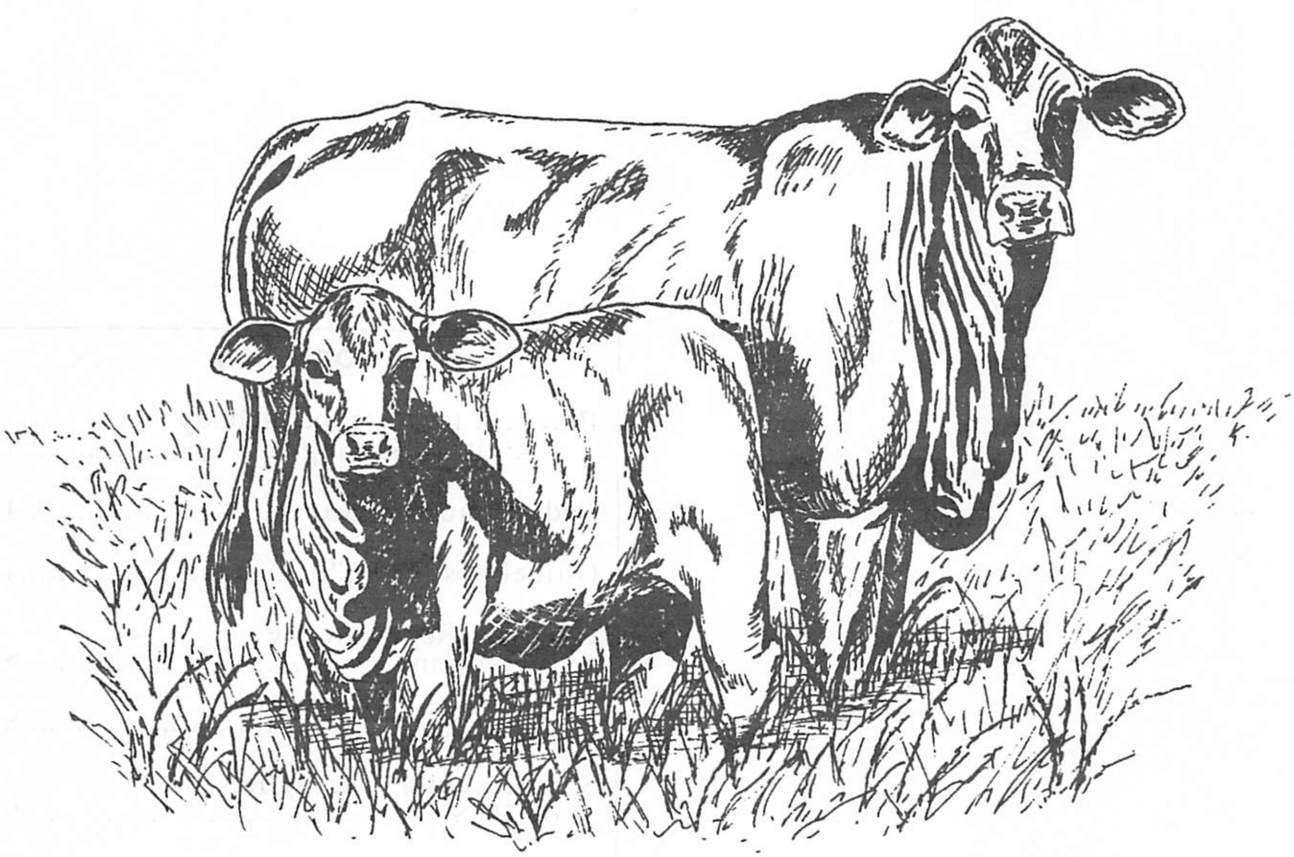
Body Condition, Nutrition and Reproduction of Beef Cows



Texas Agricultural Extension Service • Zerle L. Carpenter, Director • The Texas A&M University System • College Station, Texas

Contents

Body Condition, Nutrition and Reproduction of Beef Cows

Dennis B. Herd and L. R. Sprott*

The percentage of body fat in beef cows at specific stages of their production cycle is an important determinant of their reproductive performance and overall productivity. The amount and type of winter supplementation required for satisfactory performance is greatly influenced by the initial body reserves, both protein and fat, of the cattle at the beginning of the wintering period.

Profitability in the cow-calf business is influenced by the percentage of cows in the herd which consistently calve every 12 months. Cows which fail to calve or take longer than 12 months to produce and wean a calf increase the cost per pound of calf produced by the herd. Reasons for cows failing to calve on a 12-month schedule include disease, harsh weather and low fertility in herd sires. Most reproductive failures in the beef female can be attributed to improper nutrition and thin body condition. Without adequate body fat, cows will not breed at an acceptable rate. The general adequacy of diets can be determined by a regular assessment of body condition.

To date, there has been no standard system of describing the body condition of beef cows which could be used as a tool in cattle management and for communication among cattlemen, research workers, Extension and industry advisors. This publication's purpose is to outline a system for evaluating beef cow's body reserves and to relate the evaluation to reproductive and nutritional management. When used on a regular and consistent basis, body condition scores provide information on which improved management and feeding decisions can be made.

Practical Importance of Body Condition Scoring

Variation in the condition of beef cows has a number of practical implications. The condition of cows at calving is associated with length of post partum interval, subsequent lactation performance, health and vigor of the newborn calf and the incidence of calving difficulties in extremely fat heifers. Condition is often overrated as a cause of dystocia in older cows. The condition of cows at breeding affects their reproductive performance in terms of services for conception, calving interval and the percentage of open cows.

Body condition affects the amount and type of winter feed supplements that will be needed. Fat cows usually need only small amounts of high protein (30 to 45 percent) supplements, plus mineral and vitamin supplementation. Thin cows usually need large amounts of supplements high in energy (+ 70 percent TDN), medium in protein (15 to 30 percent), plus mineral and vitamin supplementation.

Body condition or changes in body condition, rather than live weight or shifts in weight, are a more reliable guide for evaluating the nutritional status of a cow. Live weight is sometimes mistakenly used as an indication of body condition and fat reserves, but gut fill and the products of pregnancy prevent weight from being an accurate indicator of condition. Live weight does not accurately reflect changes in nutritional status. In winter feeding studies where live weight and body condition scores have been measured, body condition commonly decreases proportionally more than live weight, implying a greater loss of energy relative to weight.

Two animals can have markedly different live weights and have similar body condition scores. Conversely, animals of similar live weight may differ in condition score. As an example, an 1,100 pound cow may be a 1,000 pound animal carrying an extra 100 pounds of body reserves, or a 1,200 pound cow which has lost 100 pounds of reserves. These two animals would differ markedly in both biological and economical response to the same feeding and management regime with possible serious consequences.

The body composition of thin, average and fat cows is illustrated in Table 1. Protein and water exist in the body in a rather fixed relationship. As the percentage of fat in the body increases, the percentage of protein and water will decrease. The gain or loss of body condition involves changes in protein and water as well as fat, though fat is the major component. Breed, initial body condition, rate of condition change and season affect the composition and energy value of weight gains or losses. Body condition scoring provides a measure of an animal's nutrition reserves which is more useful and reliable than live weight alone.

In commercial practice, body condition scoring can be carried out regularly and satisfactorily in circumstances where weighing may be impractical.

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The technique is easy to learn and is useful when practiced by the same person in the same herd over several years.

Table 1. Effect of body condition score on body composition and composition changes assuming an 1,100 pound cow at body condition score of 5.

Body condition score	3 (thin)	5 (average)	7 (fat)
Live weight/lb.	946	1,100	1,284
Composition of empty body[a]			
total weight/lb.	843	980	1,144
fat, lb.	67 (8)[b]	157 (16)	275 (24)
protein/lb.	171 (20)	181 (18)	191 (17)
water/lb.	564 (67)	598 (61)	632 (55)
mineral/lb.	39 (5)	41 (5)	44 (4)
total megacalories	700	1,107	1,647
megacalories/lb.	.83	1.13	1.44

Difference in composition	BCS 3 versus 5	BCS 5 versus 7
empty body weight/lb.	137	164
fat/lb.	90 (66)	118 (72)
protein/lb.	10 (7)	10 (6)
water/lb.	34 (25)	34 (20)
mineral/lb.	2 (<2)	3 (<2)
total megacalories	409	529
megacalories/lb.	2.99	3.23
Pounds of shelled corn required for weight gain	610	790
saved by weight loss	307	397

[a]Empty body weight is the live weight less the contents of the digestive tract.
[b]Values in parentheses are percentages.

Body Condition Scores

Body condition scores (BCS) are numbers used to suggest the relative fatness or body composition of the cow. Most published reports are using a range of 1 to 9, with a score of 1 representing very thin body condition and 9 extreme fatness. There has not been total coordination by various workers concerning the descriptive traits or measures associated with a BCS of 5. As a result, scoring done by different people will not agree exactly; however, scoring is not likely to vary by more than one score between trained evaluations, if a 1 to 9 system is used. For BCS to be most helpful, producers need to calibrate the 1 to 9 BCS system under their own conditions.

Guidelines for BCS

Keep the program simple. A thin cow looks very sharp, angular and skinny while a fat one looks smooth and boxy with bone structure hidden from sight or feel. All others fall somewhere in between. A description of conditions scores is given in Table 4.

A cow with a 5 BCS should look average—neither thin nor fat. In terms of objective measures, such as fat cover over the rib, percent body fat, etc., a BCS 5 cow will not be in the middle of the range of possible values but rather on the thin side. A BCS 5 cow will have 0.15 to 0.24 inches of fat cover over the 13th rib, approximately 14 to 18 percent total empty body fat and about 21 pounds of weight per inch of height. (See Table 2 for the range in values for all condition scores.) The weight to height ratio has not been as accurate as subjective scoring for estimating body composition. Pregnancy, rumen fill and age of the cow influence the ratio and reduce its predictive

Table 2. Best estimates of various values for the Texas system of body condition scoring[a].

Body condition score	% Fat		Carcass fat cover	Mcal/lb.		Wt./Ht.	Ratio of weight	Weight to change score as a % of wt. at BCS 5	Caloric value/ lb. wt. gain Mcal[b]
	Empty body	Carcass	inches	Empty body	Carcass	lb./in.			
1	0	.7	0	.52	.56	15.7	0.740		
								5.8	2.68
2	4	5.0	0	.67	.72	16.9	0.798		
								6.2	2.81
3	8	9.3	.05	.83	.89	18.3	0.860		
								6.7	2.95
4	12	13.7	.11	.98	1.05	19.7	0.927		
								7.3	3.09
5	16	18.0	.19	1.14	1.21	21.3	1.000		
								8.0	3.22
6	20	22.3	.29	1.29	1.37	23.0	1.080		
								8.7	3.36
7	24	26.7	.41	1.44	1.53	24.8	1.167		
								9.1	3.50
8	28	31.0	.54	1.59	1.70	26.7	1.258		
								10.2	3.63
9	32	35.3	.68	1.75	1.86	28.9	1.360		

[a]Abbreviations: Mcal = Megacalorie, wt = weight, lb = pound, in = inches, BCS = Body Condition Score.
[b]Net energy of gain. For weight loss, multiply values by 0.75.

potential. The ratio of weight to height can help separate the middle scores from the extremes.

There is controversy about whether one needs to feel the cattle to determine fatness (Figure 1) or simply look at them to assess condition scores. A recent study indicated that cattle could be separated equally well by palpation of fat cover or by visual appraisal, but the set point or average score may vary slightly depending on the method used. For cattle with long hair, handling is of value, but when hair is short, handling is probably not necessary. Keep in mind that shrink can alter the looks and feel of the cattle as much as one score. Animals in late pregnancy also tend to look fuller and a bit fatter.

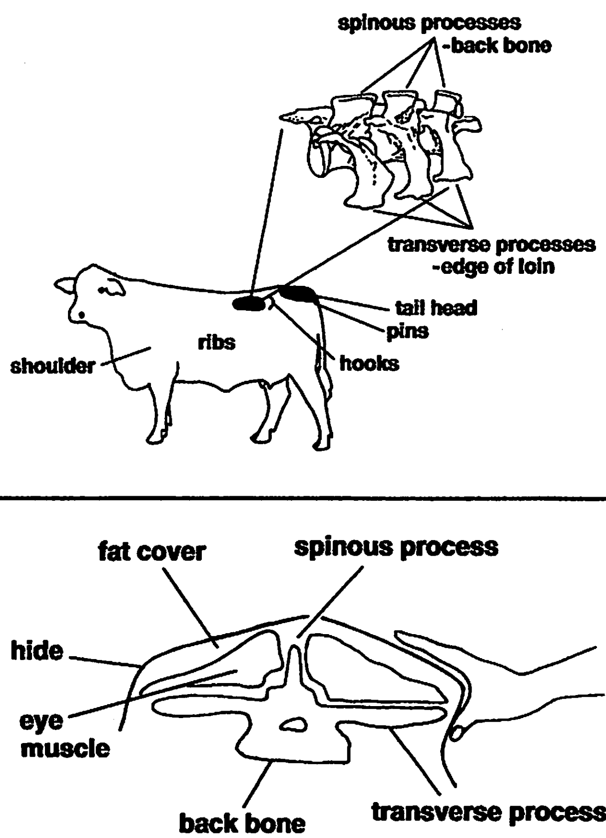


Figure 1. Anatomic areas that are used for scoring body condition in beef cows.

By recognizing differences in body conditions, one can plan a supplemental feeding program so that cows are maintained in satisfactory condition conducive to optimum performance at calving and breeding. These scores are meant to describe the body condition or fatness of a cow and have no implications as to quality or merit. Any cow could vary in condition over the nine-point system, depending on health, lactational status and feed supply.

Effect on Reproductive Performance

Calving Interval and Profitability

Calving interval is defined as the period from the birth of one calf to the next. To have a 12-month calving interval, a cow must rebreed within 80 days after the birth of her calf. Cows that do, produce a pound of weaned calf cheaper than cows that take longer than 80 days to rebreed.

In a Hardin County, Texas study, maintenance costs were compared for cows with a 12-month calving interval against those with a longer interval. Costs of production per calf from cows with intervals exceeding 12 months ranged from $19 to $133 more than for calves from cows with 12-month intervals. To compensate for increased production costs, calves from cows with extended calving intervals must have a heavier weaning weight than calves from cows with intervals of 12 months or less. Otherwise, an increase in sale price must occur. Depending on either factor for compensation is an unreasonable gamble.

BCS at Calving

The results of 5 trials which explain the effect of body condition at calving on subsequent reproductive performance are shown in Table 3. In trial 1 the percent of cows that had been in heat within 80 days after calving was lower for cows with a body condition of less than 5 than for cows scoring more than 5. Low body condition can lead to low pregnancy rates as evidenced in the other four trials. In all

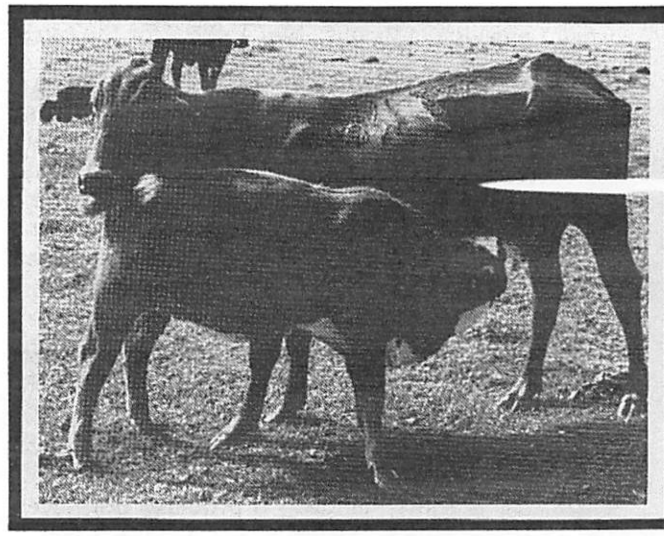
Table 3. Effect of body condition at calving on subsequent reproductive performance.

	Body Condition at Calving		
	4 or less	5	5 or more
Trial 1			
Number of cows	272	364	50
Percent in heat within 80 days after calving	62	88	98
Trial 2			
Number of cows	78	10	0
Percent pregnant after 60 days	69	80	–
Trial 3			
Number of cows	25	139	23
Percent pregnant after 60 days	24	60	87
Trial 4			
Number of cows	32	60	32
Percent pregnant after 180 days	12	50	90
Trial 5			
Number of cows	168	274	197
Percent pregnant after 60 days	70	90	92

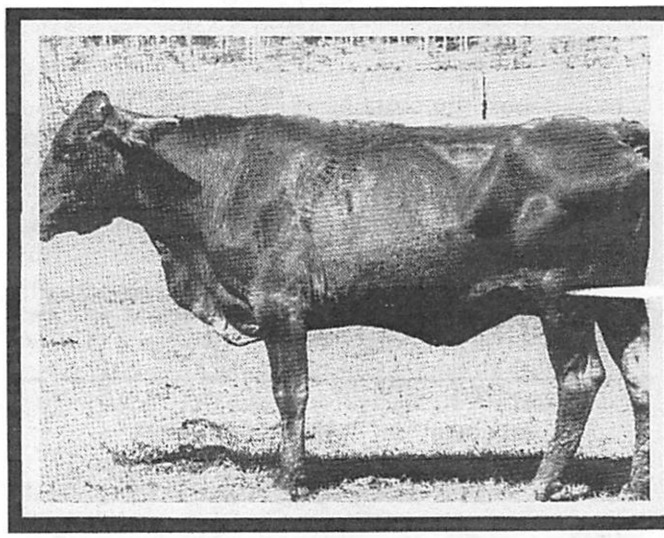
Adapted from Whitman. 1975 (Trial 1) and Sprott, 1985 (Trials 2-5).

Table 4. Description of body condition scores. Adapted from Lowman, 1976.

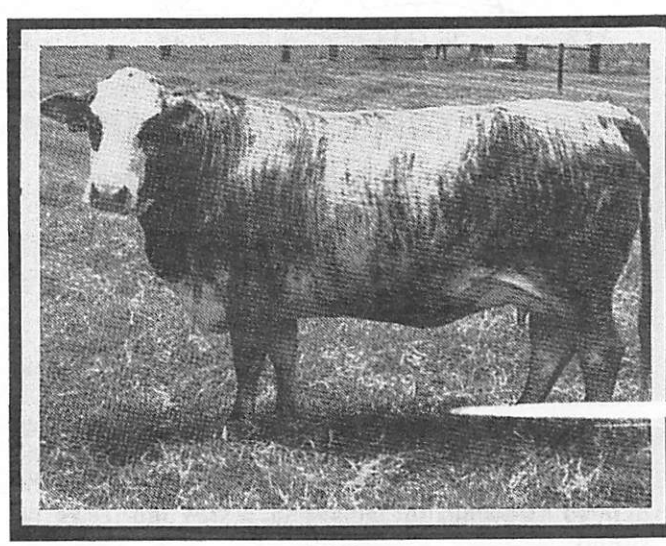
Condition	BCS	Description
Thin Condition	1	Bone structure of shoulder, ribs, back, hooks and pins sharp to touch and easily visible. Little evidence of fat deposits or muscling. (Photo 1)
Thin Condition	2	Little evidence of fat deposition but some muscling in hindquarters. The spinous processes feel sharp to touch and are easily seen with space between them. (Photo 2)
Thin Condition	3	Beginning of fat cover over the loin, back, and foreribs. Backbone still highly visible. Processes of the spine can be identified individually by touch and may still be visible. Spaces between the processes are less pronounced. (Photo 3)
Borderline Condition	4	Foreribs not noticeable; 12th and 13th ribs still noticeable to the eye particularly in cattle with a big spring of rib and ribs wide apart. The transverse spinous processes can be identified only by palpation (with slight pressure) to feel rounded rather than sharp. Full but straightness of muscling in the hindquarters. (Photo 4)
Optimum Condition	5	12th and 13th ribs not visible to the eye unless animal has been shrunk. The transverse spinous processes can only be felt with firm pressure to feel rounded—not noticeable to the eye. Spaces between the processes not visible and only distinguishable with firm pressure. Areas on each side of the tail head are fairly well filled but not mounded. (Photo 5)
Optimum Condition	6	Ribs fully covered, not noticeable to the eye. Hindquarters plump and full. Noticeable sponginess to covering of foreribs and on each side of the tail head. Firm pressure now required to feel transverse processes. (Photo 6)
Optimum Condition	7	Ends of the spinous processes can only be felt with very firm pressure. Spaces between processes can barely be distinguished at all. Abundant fat cover on either side of tail head with some patchiness evident. (Photo 7)
Fat Condition	8	Animal taking on a smooth, blocky appearance; bone structure disappearing from sight. Fat cover thick and spongy with patchiness likely. (Photo 8)
Fat Condition	9	Bond structure not seen or easily felt. Tail head buried in fat. Animal's mobility may actually be impaired by excess amount of fat. (Photo 9)



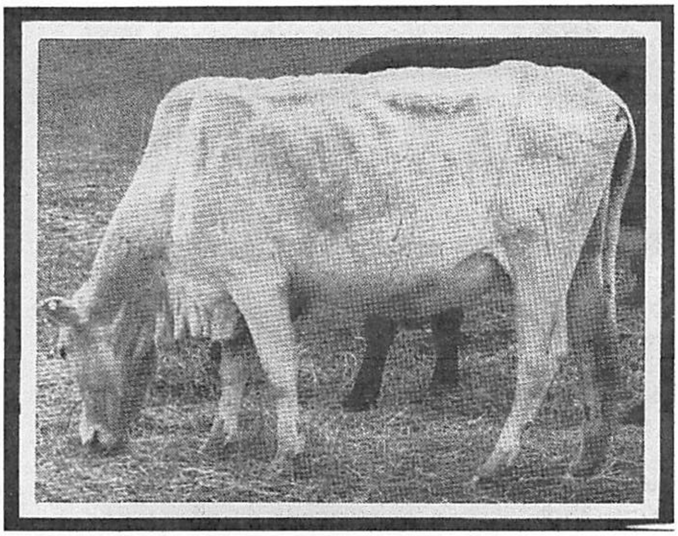
BCS 1



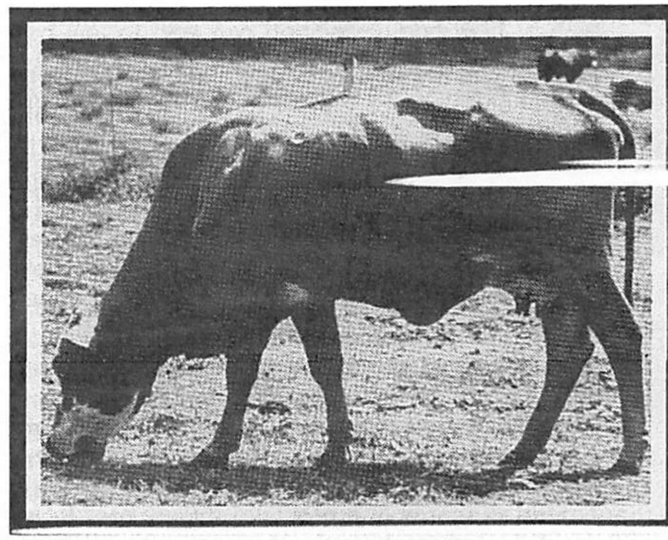
BCS 4



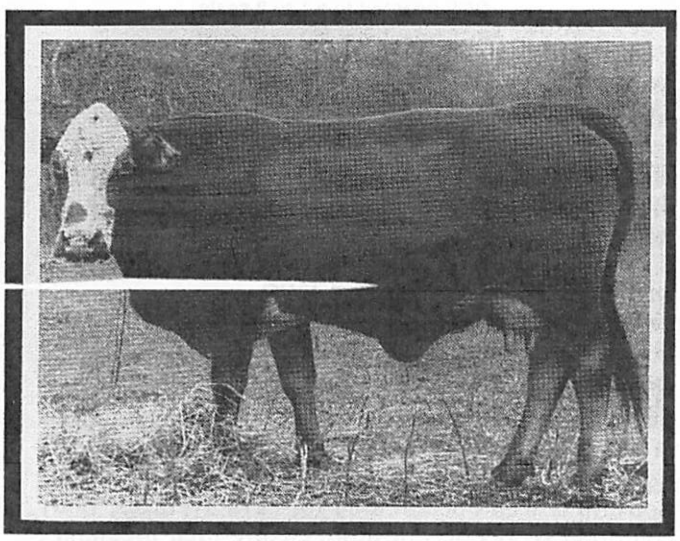
BCS 7



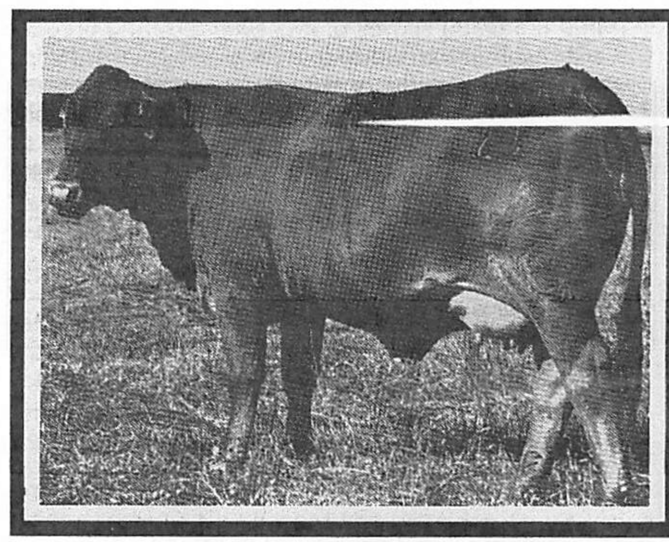
BCS 2



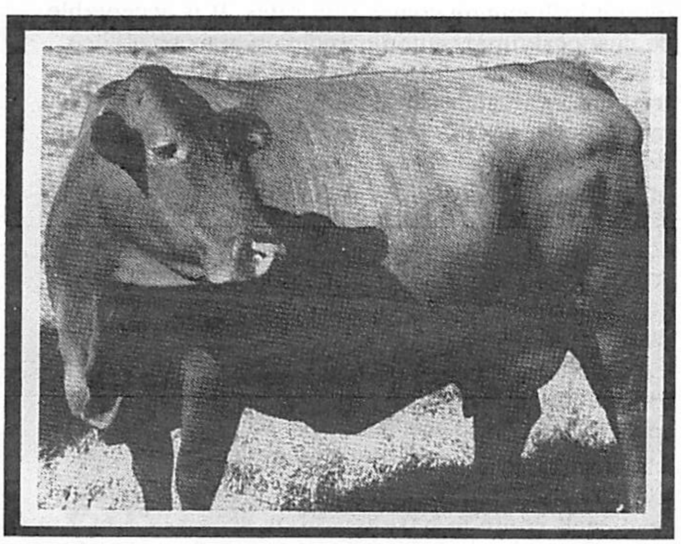
BCS 3



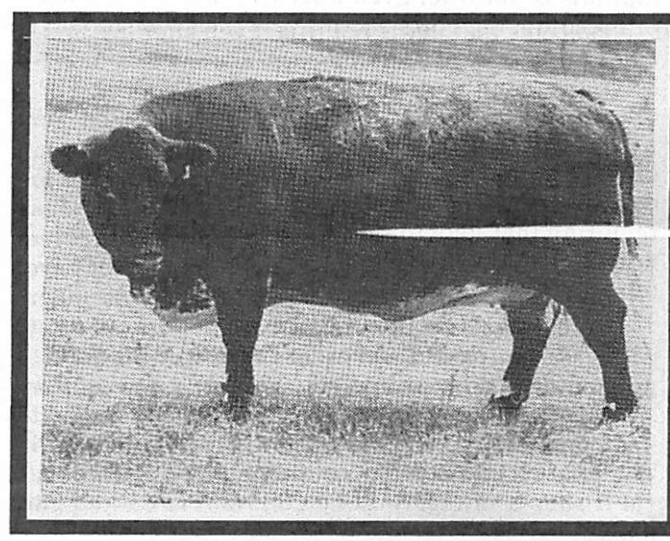
BCS 5



BCS 6



BCS 8



BCS 9

instances, cows scoring less than 5 at calving time had the lowest pregnancy rates indicating that thin condition at calving time is undesirable. The acceptable body condition score prior to calving is at least 5 or possibly 6. These should be the target condition scores at calving for all cows in the herd. Anything higher than 6 may or may not be helpful. Scores at calving of less than 5 will impede reproduction.

BCS at Breeding

Cows should be in good condition at calving and should maintain good body condition during the breeding period. Table 5 shows results of a trial involving more than 1,000 cows where the effect of body condition during the breeding season on pregnancy rates was studied. That trial supports the fact that condition scores of less than 5 during breeding will result in extremely low pregnancy rates. Proper nutrition during the breeding season is necessary for acceptable reproduction.

Table 5. Effect of body condition during the breeding season on pregnancy.

	Body condition during breeding		
	4 or less	5	6 or more
Number of cows	122	300	619
Percent pregnant after 150 days	58	85	95

(Sprott, 1985.

Long Breeding Seasons Not the Answer

Some producers believe long breeding seasons are necessary to achieve good reproductive performance. Evidence in Table 3—Trial 4 and Table 5 indicates that this is not true. Even after five and six months of breeding, the cows scoring less than 5 at calving and during breeding did not conceive at an acceptable level. Until they have regained some body condition or have had their calf weaned, most thin cows will not rebreed regardless of how long they are exposed to the bulls. Trials have shown that thin cows may take up to 200 days to rebreed. Cows requiring that long to rebreed will not have a 12-month calving interval, which subsequently reduces total herd production.

Calving intervals in excess of 12 months are often caused by nutritional stress on the cow at some point either before the calving season or during the subsequent breeding season. This results in thin body condition and poor reproductive performance. The relationship of body condition to calving interval is shown in Figure 2. The thinnest cows have the longest calving intervals while fatter cows have shorter calving intervals. Producers should evaluate their cows for condition and apply appropriate supplemental feeding practices to correct nutritional deficiencies which are indicated when cows become thin. These deficiencies must be corrected or reproductive efficiency will remain low for cows in thin body condition.

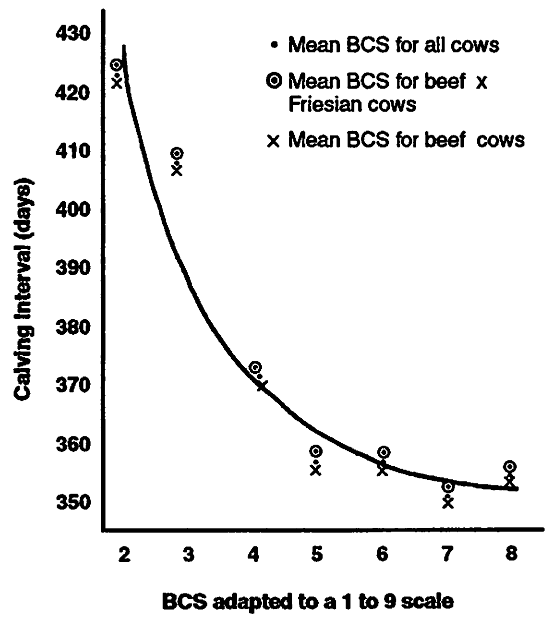


Figure 2. Relationship between cow body condition score at mating and subsequent calving interval. (Adapted from Kilkenny, 1978.)

Critical BCS

Groups of cows with an average BCS of 4 or less at calving and during breeding will have poor reproductive performance conpared to groups averaging 5 or above. Individual cows may deviate from the relationships established for groups; however, the relationship is well documented for herd averages. Body condition scores of 5 or more ensure high pregnancy rates, provided other factors such as disease, etc., are not influencing conception rates. It is acceptable for cows calving regularly to obtain a score of 7 or more through normal grazing, but buying feed to produce these high condition scores is uneconomical and not necessary.

It is desirable to maintain cows at a BCS of 5 or more through breeding. This implies that cows scoring less than 5 at calving need to be fed to improve their condition through breeding, which is expensive to accomplish while they are nursing calves. If cows scoring 5 or less lose condition from calving to breeding, pregnancy rates will be reduced. Cows scoring 7 or 8 can probably lose some condition and still breed well provided they do not lose enough to bring their score below 5.

An efficient way to utilize BCS involves sorting cows by condition 90 to 100 days prior to calving. Feed each group to have condition scores of 5 to 7 at calving. These would be logical scores for achieving maximum reproductive performance while holding supplemental feed costs to a minimum.

Supplemental Feeding Based on BCS

Regular use of BCS will help evaluate the body composition or fatness of cattle in a fairly accurate and rather easy manner. Cows which score 5 or more and still have reproductive problems likely have a mineral or vitamin deficiency, disease or genetic problem, or the problem may exist with the bull. Cows scoring less than 5 may not be receiving adequate levels of energy (total feed with reasonable quality) and protein, although other factors such as phosphorus and internal parasites may be involved. A combination of these nutritional problems is frequently observed.

In a commercial cow-calf program, the digestible energy requirement of the cow and calf should come from forage produced on the operator's farm or ranch. Purchasing large amounts of energy supplements on a regular basis is not economically feasible. A cow's energy deficit periods must be satisfied from body stores established during periods of forage surplus. Protein, mineral and vitamin supplements facilitate this process efficiently from both a biological and economical basis. The higher sale value of purebred cattle can make replacement of forage-energy with grain-energy economically feasible and often necessary for extra condition and marketing or sales appeal. Purebred breeders need to remember that their cattle should fit the production environment of their commercial customers, minimizing grain input, if they expect repeat sales.

Numerous supplemental feeds are available in a variety of different forms. None of the supplements are best suited for all situations. The body condition of the cow, lactation status and quality of forage are major factors to consider in choosing a supplement. The influence these factors have on supplementation requirements is illustrated in Tables 6 and 7 for a cow that weighs 1,000 pounds at BCS 5. Producers should remember that other factors also influence nutritional requirements, such as weight, mature size, breed type, milk production level, travel and environmental stresses.

Body condition significantly alters the requirement for supplemental energy and slightly alters the need for supplemental protein, but it is not a determining factor of mineral or vitamin supplementation. Mineral supplementation with emphasis on salt, phosphorus, magnesium, copper, zinc and calcium is advisable in all situations. Vitamin A supplementation may not be needed with excellent forage, unless it is hay stored for a lengthy period. Vitamin A should be supplemented, especially for lactating cows, with lower quality forages regardless of body condition.

All cattle, fat or thin, need protein supplementation to consume and utilize low quality forage with any degree of effectiveness. Protein supplementation is recommended with low quality forage regardless of the BCS or lactation status of the cow. The efficiency of response to protein supplementation is normally greater than that to energy.

Table 6. Pounds of feed needed daily by a pregnant 1,000 pound cow (last 1/3 of gestation) of varying body condition, when fed forage of varying quality, assuming fleshy cows will be allowed to lose weight (1.33 lb./day) and condition and thin cows will be fed to increase weight (+1.33 lb./day) and condition.[a]

	Pasture, Range or Hay Quality								
	Excellent 13% Crude Protein 52% TDN[b] .51 Mcal NE_M[c]			Average 7.5% Crude Protein 47%TDN .43 Mcal NE_M			Poor 4% Crude Protein 42% TDN .35 Mcal NE_M		
Condition score of cows	3	5	7	3	5	7	3	5	7
Cow weight/lb.	860	1,000	1167	860	1,000	1,167	860	1,000	1,167
Required by cow									
Crude Protein/lb.	1.9	1.5	1.2	1.9	1.5	1.2	1.9	1.5	1.2
NE_M, Mcal	13.4	9.5	6.2	13.4	9.5	6.2	13.4	9.5	6.2
Hay/lb.	24.7	18.7	12.2	20.2	22.0	16.0	16.7	18.3	15
Cottonseed meal/lb.	--	--	--	--	--	--	1.5	1.5	1.5
Milo or corn/lb.	1	--	--	5.5	--	--	7.5	2.5	--

[a]At 1.33 pounds per day, 105 days would be required for the thin cow to reach a BCS of 5, 125 days would pass before the fleshy cow would drop down to a BCS of 5. When feed is available and reasonably priced, it may be desirable to save some of the condition on the BCS 7 cow for a later time, e.g., a drought where feed will be scarce and expensive.

[b]Total Digestible Nutrients.

[c]Megacalories of Net Energy for Maintenance (used as basis for calculations).

Table 7. Pounds of feed needed daily by a 1,000 pound lactating cow (14 lbs. milk/day) of varying body condition, when fed forage of varying quality, assuming the fleshy cows will be allowed to lose weight (-1.33 lb./day) and condition and the thin cows will be fed to increase weight (+1.33 lb./day) and condition.[a]

	Pasture, Range or Hay Quality								
	Excellent 13% Crude Protein 52% TDN[b] .51 Mcal NE_M[c]			Average 7.5% Crude Protein 47% TDN .43 Mcal NE_M			Poor 4% Crude Protein 42% TDN .35 Mcal NE_M		
Condition score of cows	3	5	7	3	5	7	3	5	7
Cow weight/lb.	860	1,000	1,167	860	1,000	1,167	860	1,000	1,167
Required by cow									
Crude Protein/lb.	2.6	2.2	1.9	2.6	2.2	1.9	2.6	2.2	1.9
NE_M, Mcal	17.5	13.5	10.2	17.5	13.5	10.2	17.5	13.5	10.2
Hay/lb.	26.0	26.5	20.0	21.9	23.7	23.0	17.5	19.0	19.5
Cottonseed meal/lb.	--	--	--	1.0	1.0	1.0	2.5	2.5	2.0
Milo or corn/lb.	5.0	--	--	8.0	3.0	--	11.0	6.0	2.5

[a]At 1.33 pounds per day, 105 days would be required for the thin cow to reach a BCS of 5, 125 days would pass before the fleshy cow would drop down to a BCS of 5. When feed is available and reasonably priced, it may be desirable to save some of the condition on the BCS 7 cow for a later time, e.g., a drought where feed will be scarce and expensive.

[b]Total Digestible Nutrients.

[c]Megacalories of Net Energy for Maintenance (used as basis for calculations).

There are limits, however, to the improvement in animal performance that can be achieved with protein supplementation. if protein supplementation will not result in satisfactory performance, large amounts of grain-based supplements (including protein) must be fed or a better forage must be used.

Whether energy supplementation or grain feeding is necessary depends largely on the lactation status and BCS of the cows and the quality of forage. Grain feeding is recommended only as a last resort since it is normally expensive and has negative associative effects on the efficiency with which cattle utilize forage. The depressing effect of grain feeding on forage digestion is greatest when large amounts are fed infrequently. Depressing effects result from reductions in rumen pH, changes in the rumen microbes and antagonistic alterations in the rate of passage of each feed through the digestive tract. Where energy supplementation is necessary in order to sustain a desired level of performance, provide small amounts at frequent intervals.

Protein and energy should be in proper balance. If protein is in excess compared to the level of energy, the excess protein will be used for energy. Although high protein feeds are good energy feeds, they are usuallly quite expensive sources of energy. Adding a high energy supplement to a forage that is deficient in protein will result in a total diet that is deficient in protein and poor utilization of total dietary energy. Timely use of energy in combination with protein supplements is often necessary with typical forage programs to properly develop replacement heifers and supplement heifers with their first calf. Mature cows should not need much energy supplementation on a routine basis.

Nutritional Management

Many cows in Texas need a higher level of condition at calving and breeding to improve reproductive performance and income. Grain feeding can be used to maintain or increase body condition, but this approach has economic limitations. Tables 6 and 7 illustrate that cows receiving higher quality forage require little or no grain supplementation, especially dry pregnant cows. Dry pregnant cows can utilize low quality forage without excessive grain supplementation. Cows with body condition scores of 6 to 8 can lose some condition without reducing performance and therefore need little, if any, grain.

With these points in mind, producers should choose a calving season that is compatible with their forage program, use a good mineral program which improves body condition year-round due to improved forage utilization, and consider protein supplementation whenever forage protein is less than 7 percent on a dry matter basis (e.g., summer drought pasture, mature frosted grass, etc.). Since protein supplementation stimulates the intake and digestion of low protein forage (< 7 percent), body condition can be improved on droughty summer pasture and condition losses can be decreased on dormant winter pasture. This approach minimizes the amount and expense of energy supplementation, but may not eliminate it completely. Where minerals, vitamins and protein are furnished in adequate amounts, but body condition continues to decline, large amounts of energy supplementation will be required to stop further decline or to produce an improvement. Because combinations of low quality forage and grain are used so inefficiently, it would be more economical to produce or buy a higher quality forage when high levels of animal performance are desired.

If the requirement for energy supplementation is a yearly necessity, a change in management is suggested. The supply of nutrients from forage must be increased, both in quality and quantity, or the nutritional requirements of the cattle must be reduced (cattle with less milk potential and probably smaller in size). The stocking rate of many herds needs to be reduced to allow a greater volume of forage for each animal thus reducing the need for so much supplement.

Summary

A BCS of 5 or more (at least 14 percent body fat) at calving and through breeding is required for good reproductive performance. Over-stocking pastures is a common cause of poor body condition and reproductive failure. Proper stocking, year-round mineral supplementation and timely use of protein supplements offer the greatest potential for economically improving body condition scores and rebreeding performance of beef cows in Texas. Sorting cows by condition 90 to 100 days ahead of calving and feeding so that all cows will calve with a BCS of 5 to 7 will maximize reproductive performance while holding supplemental feed costs to a minimum. Nutritional and reproductive decisions, so important to profitability, are made with more precision and accuracy where a body condition scoring system is routinely used.

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Producing and Marketing High-Value Calves

Jason J. Cleere and Larry L. Boleman*

With production costs increasing and calf prices remaining fairly stable, cow-calf producers are searching for ways to add value to calves and make their operations more profitable. While individual producers can not influence average market prices, they can control some of the price variation at auctions and other market outlets by following sound market-management practices. It is very important to market the types of calves buyers demand. Successful producers develop management and marketing strategies that will ensure premiums for their calf crop.

Breeding Herd Management

Much of the eventual market value of a calf is determined 16 to 19 months before it is marketed. Market acceptance is important when choosing breeds. The prices received for cattle based upon breed, breed combinations or type are not always warranted, but the careful producer always considers the types of calves buyers are demanding. Breeds and mating programs should be planned carefully because short-term market preferences may occur rapidly and cause severe price fluctuations, while breeding programs can not be changed as quickly. It is pointless to produce heavier calves if they will be discounted because of poor market acceptance.

It is important to use cows that fit the environment. If heifers are to be retained for replacements, the bull must also fit that same environment. If heifers are not retained (a terminal cross), then the producer has the flexibility to select a bull to complement the cow's genetics and produce a calf that the buyers demand.

Calving season

Once the bull is placed with the cow herd, the breeding and calving seasons are determined. The calving season and length of the breeding season determine when to sell a weaned calf. In Texas, there are basically two calving seasons: fall and spring. Calves born in the spring (January through March) generally cost less to produce and will be 25 to 50 pounds heavier than fall calves (September through November). The reason for the lower cost of production is that dry cows have lower nutritional requirements than lactating cows and will need less feed during the winter. The key is to match the time when the cow has the highest nutritional requirement (approximately 2 months after calving) to a time when there is a good supply of forage available (typically in the late spring). However, the disadvantage of a spring calving season is that calves usually are sold during the fall when the market is usually lowest (Fig. 1). Calves born in the fall are usually marketed in the spring when prices are highest, but those calves weigh less (unless winter pasture or supplement is provided) and cost more to produce

Breed, type, condition, weight and sex

Prices received for stocker and feeder cattle depend on the quality of the animals. Stocker and feeder calf buyers use their knowledge and experience to visually identify calves that will excel in feed efficiency, average daily gain, and carcass quality. Visible traits that affect quality in feeder cattle include breed, color, condition,

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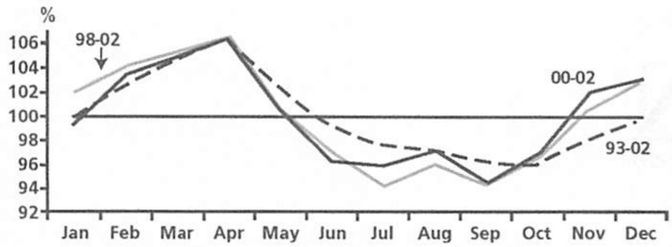
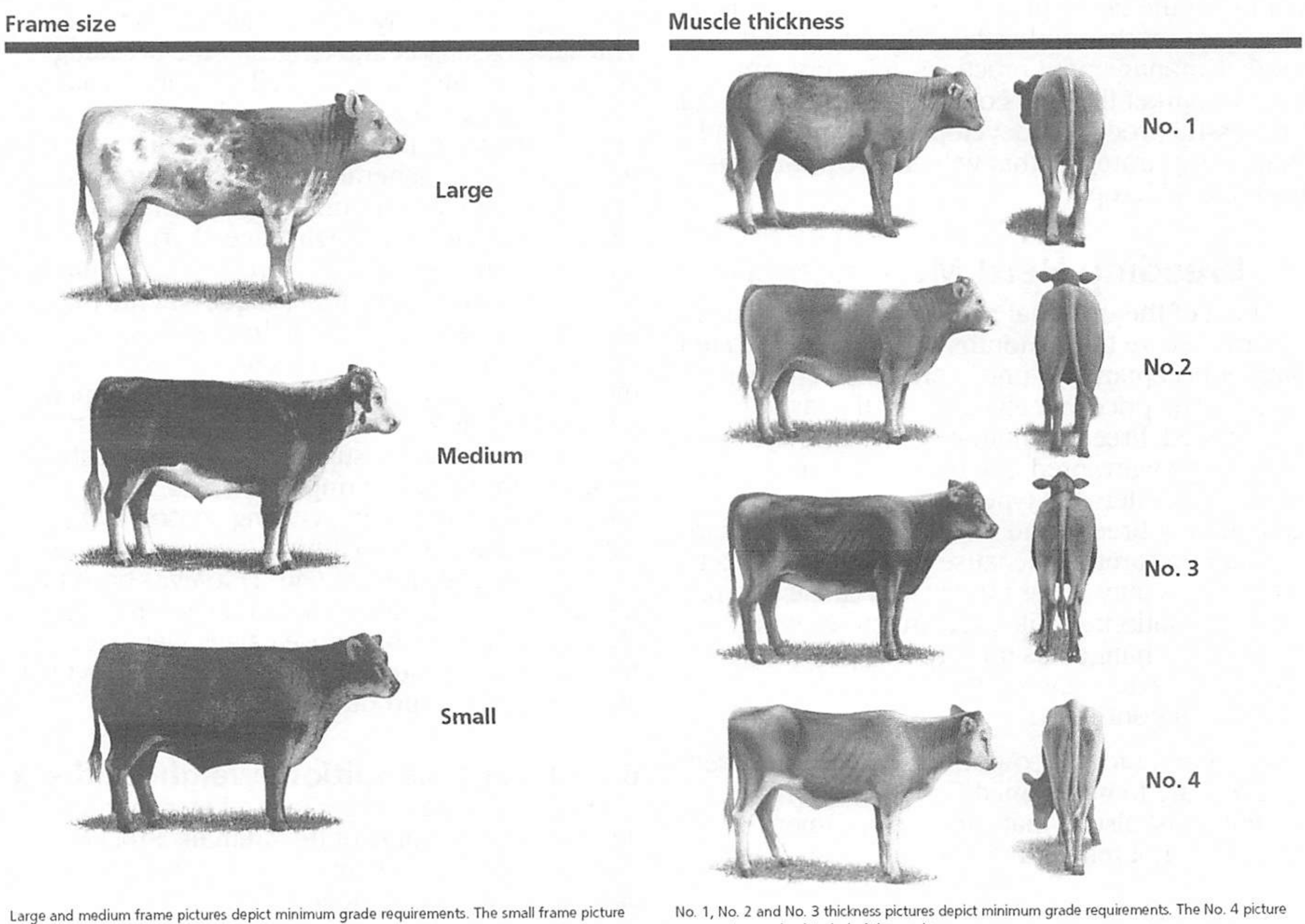


Figure 1. Seasonal price indices (3-, 5- and 10-year) for 400- to 500-pound steers in Amarillo (Davis and Brown, 2003).

sex, frame and muscling. The level of discounts for cattle that do not meet quality standards will vary depending on the supply of cattle available. If there is an abundant supply of cattle, buyers can be more selective and discount inferior cattle more.

Frame. Feeder cattle are divided into three frame scores as outlined by the U.S. Department of Agriculture (Fig. 2): USDA Small (S), Medium (M), or Large (L). A small-frame steer is expected to be market ready (0.5 inch of fat cover) at a live weight of less than 1,100 pounds. Medium-frame steers are expected to finish at 1,100 to 1,250 pounds. Large-frame steers are expected to finish at more than 1,250 pounds. Heifers would be expected to finish 100 pounds lighter than steers. Large- and medium-frame cattle will gain faster and possibly more efficiently than small-frame cattle and are not likely to produce price-discounted lightweight or overfinished carcasses. Oklahoma State University (Smith et al., 2000) and University of Arkansas (Troxel et al., 2001) researchers conducted livestock market surveys to determine factors that affect value in feeder cattle. Their data indicate that small-frame cattle bring $18 to $19 less per cwt than large-frame cattle and that large-frame cattle bring $1 to $4 more per cwt than medium-frame cattle.

Muscling. The USDA feeder cattle muscle scores are USDA No. 1 (moderately thick), 2 (slightly thick), 3 (thin), and 4 (animal below a No. 3 grade). The Arkansas study revealed that No. 1 steers received a $4.72 premium over the No. 2 steers and that the No. 2 and No. 3 steers were discounted $13.40 and $22.65 when compared



Large and medium frame pictures depict minimum grade requirements. The small frame picture represents an animal typical of the grade.

No. 1, No. 2 and No. 3 thickness pictures depict minimum grade requirements. The No. 4 picture represents an animal typical of the grade.

Figure 2. U.S. frame and muscle thickness standards for feeder cattle (Adapted from USDA, 2000).

to the No. 1 steers. Muscle is important to the value of feeder cattle and it is important to select breeding cattle that will produce calves with adequate muscling.

Body condition. The Oklahoma study found that thin cattle received discounts of $9 to $10 per cwt when compared to cattle of average condition, and that fat cattle received discounts of $6 to $11 per cwt. Fat feeders may be discounted because buyers expect their efficiency of gain to be poor. Thin feeders may be discounted because buyers fear they may be more susceptible to health problems and death.

Breed effects. Recognizable breeds and crosses with characteristics reflecting differences in performance (such as maturity, frame size, muscling, condition and ultimate USDA grading standards) generally follow pricing patterns similar to those described. Cattle with a high percentage of dairy breeding, extremes of any kind, and most purebreds (unless purchased for specialized markets) are penalized. Color (red, black, yellow, etc.), which is influenced by breed, has very little effect on feeder prices. However, prices for spotted cattle typically are lower than those for solid-pattern feeders. The Arkansas study indicated a $10-per-cwt discount for spotted cattle.

Gender. Steers typically command the highest price, followed by bulls and then heifers. Heifers in the 400- to 500-pound range will be priced at $7 to $10 less per cwt than steers, while bulls will be discounted $3 to $6 per cwt when compared to steers. Discounts for bull calves usually depend on weight. Heavier calves will be discounted more because older, larger bulls experience more stress during castration. Castration is a simple and inexpensive way producers can add value to bull calves. The downside to castration is that steer calves will be 15 to 25 pounds lighter than bull calves at weaning. This can be offset by using growth implants to increase the weaning weights of steer calves.

Calf Crop Management

After producing top-quality calves that will be acceptable in the market, producers must manage those calves properly to avoid any possible discounts. Buyers look for well-managed, healthy, thrifty cattle that have been dehorned, castrated and vaccinated. Producers should also evaluate other cost-effective management practices that can increase weaning weights and, ultimately, the value of calves.

Health and thriftiness

Data from Texas A&M University's "Ranch to Rail" program show that sick cattle in the feedlot are more likely to die than healthy cattle. They also will have higher medical costs, reduced feed efficiency, reduced carcass quality, and lower net returns than cattle that remained healthy during the feeding period. Thus, discounts for sick or "high risk" cattle can be severe.

The demand for preconditioned feeder calves is growing; preconditioned calves typically receive a $3 to $6 premium over non-preconditioned calves. A preconditioning program consists of administering recommended vaccinations and carrying out a weaning program that may not pay unless the producer markets in a way that will reward him for the added time and expense. Additional information on preconditioning can be found in Texas A&M University Department of Animal Science publications: ASWEB-120, "Value Added Calf (VAC)–Management Programs" and ASWEB-076, "Value Added Calf (VAC)–Vaccination Programs." Also see Texas Cooperative Extension publication L-5295, "Immunizing Beef Calves: A Preconditioning Immunization Concept."

Dehorning

In the feedlot, horned cattle require more bunk space, can cause bruises that lower carcass values, and are a safety concern for people. Discounts for calves with horns are usually about $2 per cwt and can be avoided easily. Dehorning is inexpensive and should be done as young as possible to reduce the stress on the calf. Methods and devices used to dehorn calves include polled genetics, hot iron method, Barnes dehorner, dehorning saw, tube dehorner, and dehorning paste.

Castrating

Producers should castrate bull calves because, depending on weight, steers are worth $3 to $6 more per cwt. The older and heavier bull calves are, the more they are discounted to allow for shrink and possible death loss from castration. Castrate calves as young as possible, preferably before 4 months of age, to minimize stress and risk. Calves can be castrated as soon as they are nursing. Methods of castration include surgery (knife cut), banding and the burdizzo method.

Growth implants

Producers should strongly consider implanting suckling calves because there is a high net return on this investment. An implant costs about

$1.00. Implanting suckling calves will increase daily weight gains by 0.10 to 0.14 pounds (Selk, 1997) and weaning weights by 20 to 25 pounds. Implanting heifers intended for replacements does not benefit production or profit, so it is not recommended. For more information on implants and procedures for implanting cattle, see Texas Cooperative Extension publication L-2291, "Beef Cattle Implants."

Parasite control

Calves are more susceptible to internal and external parasites than adult cattle and managing these parasites can add additional pounds of weaning weight. Texas field trials indicate that deworming nursing calves along with their dams in the spring can increase daily weight gains in calves by 0.1 to 0.2 pounds (Wikse et al., 1998). This increases weaning weights by 25 pounds for a cost of only $3.50 to deworm each cow-calf pair.

Controlling external parasites also improves weaning weights. At an infestation level of more than 250 flies per animal, controlling horn flies on cows and calves has added 15 to 20 pounds of weaning weight.

Creep feeding

Creep feeding is designed to add weight to nursing calves on pastures. It is rarely advantageous under normal conditions because of the high cost per additional pound of gain. Calves on high-energy creep feed will require 9 to 15 pounds of feed per pound of additional gain. Poor feed efficiency, coupled with the declining value of gain, usually makes creep feeding undesirable. Producers should evaluate current market conditions and feed costs to determine if this practice can be profitable. However, if cows and calves are stressed by a lack of forage, extreme temperatures, or other adverse environmental conditions, creep feeding could be advantageous, especially if high-protein feeds are used.

Fill

A small amount of fill variation is tolerated by order buyers, but extremes are discounted. Cattle fill is classified as gaunt, shrunk, average, full or over-filled (also called tanked). The Arkansas study indicated that gaunt or severely shrunken cattle were discounted $4 per cwt, while over-filled cattle were discounted $9 per cwt. Keeping cattle within the shrunk-average-full range should eliminate discounts for fill.

Group size and uniformity

Buyers prefer feeders that are bred alike, managed alike, and sold in truck load lots (90 to 100 head). When determining uniformity among a group of feeder cattle, the traits buyers look for most are weight, color, breed type, frame, muscle and condition. Premiums for selling in group lots range from $1 to $7 per cwt depending on the group size.

Marketing Strategies

Successful producers study market opportunities and develop a market strategy months in advance. Producers should study market timing, the prevailing prices, and market trends to determine the best time to market. They should explore marketing alternatives that can help them receive the best price. Auction markets, direct sales, video or internet sales, commingled sales and retained ownership are some marketing alternatives that may be available. These are discussed in detail in the Texas Cooperative Extension publication "L-2225, Beef Cattle Marketing Alternatives."

Auction markets

Auction markets are the most common choice for smaller producers. There are some strategies producers can use to help maximize auction prices.

Markets differ in appearance, facilities, number of cattle handled, type and number of buyers who attend, and the amount of service given to sellers. Prices can vary considerably from market to market and it is up to the seller to research available auctions to determine which one can help you receive the best value for your calves. Producers should alert the market manager in advance if they have cattle that might be marketed better in some special manner. For example, if it is time to sell your weaned set of 20 good quality, uniform steers, then notify the manager. It may be possible for him to sell them as a group or at least give some additional information on the calves to the buyers.

Shrink is another factor that can significantly affect the total value received for calves. Calves begin to shrink soon after they are weaned. Shrink can be as high as 10 percent in calves weaned and shipped the day before the sale if they do not have access to hay and water. Minimizing shrink begins when cattle are gathered. Be sure to minimize the stress placed on the calves during penning, sorting and hauling. Do not crowd calves. Transport them directly to sales and avoid letting them stand in the hot sun for long periods. Consult with the auction manager about ways to reduce shrink before your calves are sold.

Summary

There is no way to guarantee cattle will always bring top market prices, but with proper management and marketing procedures, discounts can be prevented. Begin by producing the kind of calf that is in demand. Implement management practices that will prevent discounts and spend ample time marketing the calves you worked all year to produce.

For Additional Information

Texas Cooperative Extension publications are available at *http://tcebookstore.org*.

Also see the Texas A&M Animal Science Extension Web site at *http://animalscience.tamu.edu.*

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Animal Welfare and the "Five Freedoms"

Ron Gill, Ph.D., Professor and Extension Livestock Specialist

Animal welfare issues have received more attention in the press over the last few years than they had the previous century. The livestock production system and its owners and managers have paid attention to animal welfare for centuries. It was just called animal husbandry for many decades and over the past three decades or so it became known as animal science.

In reality, Science and Husbandry were woven together by using the latest in technology and science to improve efficiencies in animal production while at the same time keeping the best interest of the animal at the forefront. The problem became that the focus and topic of conversation was always on the science and little to no focus on communicating the husbandry aspect of modern production principles.

In a society where a portion of the population has little to worry about, particularly in regard to an abundant, quality food supply and access to instant mass communication the concerns and voices of a small but vocal minority can seem like an uprising of society against agriculture and the science based production systems. It is encouraging when survey work indicates that in excess of 96% of the population is in favor of consuming animals for food if they are treated humanely during their growth or production phase when most press they are exposed to related to animal issues is negative.

It important that farmers and ranchers recognize appreciate this vote of confidence in our production systems and realize how important the last part of that vote of confidence is, "if they are treated humanely". We are responsible to the animals and our customers to ensure that all livestock and poultry are treated humanely throughout their life.

A couple of years ago the first reference to the concept of Five Freedoms was from Dr. Tom Noffsinger as we were conducting low-stress livestock trainings for Texas Cattle Feeders Association members. To me the five freedoms referenced made perfect sense. As I looked into the five freedoms Dr. Noffsinger had referenced I discovered the history and origin of this list of freedoms.

Anytime you reference "freedoms" for animals it immediately draws the ire of industry because it brings up images of the fights fought relative to animal rights. Although the activists groups have done a great job of limiting the use of the term "animal rights" and use a more palatable term "animal welfare" in their messages put out to the general public, the animal production industries fully understand the underlying motivation for most of the leaders of these "animal welfare" groups. Most of them had a long history of animal rights advocacy prior to becoming leaders of the more middle of the rode animal welfare advocacy groups. There is complete justification for the skepticism of the producers of animals intended for human consumption have about the current leadership of those groups.

However, these Five Freedoms did not originate from these advocacy groups and a little history of the concept is justified. The concept of Five Freedoms originated with a Report in the UK of the Technical Committee charged to Enquire into the Welfare of Animals kept under Intensive Livestock Husbandry Systems, the Brambell Report was delivered in December 1965. This stated that farm animals should have freedom "to stand up, lie down, turn around, groom themselves and stretch their limbs," a list that is still sometimes referred to as Brambell's Five Freedoms.

As a direct result of this Brambell Report, the UK established a Farm Animal Welfare Advisory Committee (FAWAC). This group quickly became the Farm Animal Welfare Council (FAWC) which was established by the British Government in July 1979. Since that time under the direction of the Farm Animal Welfare Council, Brambell's Five Freedoms were modified to account for more concern and attention to behavior and were eventually modified to represent the following Five Freedoms.

Five Freedoms

1. **Freedom from thirst, hunger and malnutrition** - by ready access to fresh water and a diet to maintain full health and vigor.
2. **Freedom from discomfort** - by providing a suitable environment including shelter and a comfortable resting area.
3. **Freedom from pain, injury and disease** - by prevention or rapid diagnosis and treatment.
4. **Freedom to express normal behavior** - by providing sufficient space, proper facilities and company of the animals own kind.
5. **Freedom from fear and distress** - by ensuring conditions that avoid mental suffering.

As you look over the Five Freedoms keep in mind the following statement and acknowledgment by Dr. John Webster. According to Dr. John Webster: (The researcher who helped develop the Five Freedoms, and Professor of Animal Husbandry, (University of Bristol)

"When put to work by comparing different housing systems, the five freedoms are an attempt to make the best of a complex situation. ***Absolute attainment of all five freedoms is unrealistic.*** *By revealing that all commercial husbandry systems have their strengths and weaknesses, the five freedoms make it, on one hand, more difficult to sustain a sense of absolute outrage against any particular system such as cages for laying hens or stalls for sows and easier to plan constructive, step by step, routes towards its improvement."*

As a livestock producer myself I have a really hard time seeing where we can argue with the concept of these Freedoms. I also think it is important to note that production of livestock in non environmentally controlled settings make some of this much more difficult to ensure. With that said I think it is important that every producer of livestock or poultry try to accomplish these freedoms.

If anyone disagrees with the responsibility of the owner/manager to provide ready and ample access to water and feed to maintain health and vigor they should remove themselves from agriculture immediately. That is how we make a living. Provide nutrition and let the natural process of growth occur so we can capture sunlight in a saleable product.

Freedom from discomfort is probably the one that causes as much discussion as any of the freedoms in cattle production. Because we are not an intensive confined animal industry environmental control is not possible. However, I do think it is everyone's best interest to provide cattle with ability to protect themselves from the environmental extremes as much as possible. Perhaps our most vulnerable areas are in extreme heat without adequate shade and extreme cold without protection from wind. In my opinion we need to rethink shade in confined livestock operations. Although it is difficult to show an economic advantage to providing shade the recent problems with heat stress in feeding operations makes me think we need to reevaluate this area of husbandry.

Freedom from pain, injury and disease is another freedom that has some pushback from the industry and I completely understand that because of one word in the list and that is pain. There is no such thing as a pain free or even risk free existence for humans or livestock. It is the responsibility of the manager of livestock to manage the severity of pain for the animal. It is always in the best interest of productivity to manage pain, prevent injury and disease and treat as quickly as possible in the event of injury or disease.

The area of pain management in livestock production will be the next area of concern that cattle producers will have to address whether we want to or not. If we adhere to the *The Cattle Industry's Guidelines for Care and Handling of Cattle* (NCBA 2003) pain management will not be a major concern. Dehorning and castration are the two areas where the industry must come to grips with the "when and how" to best manage these practices. If done early in life there is much less pain associated with these procedures. After a certain age intact male may have to be handled by different procedures, pain mitigation, or left intact through finishing. Dehorning should only be done early in life unless pain management is utilized. The industry has already adopted that philosophy for the most part.

Freedom to express normal behavior is an area where the beef production sector is on as solid a ground as any livestock enterprise can be. In every phase of traditional beef cattle production cattle are managed in groups and have ample room to express normal behavior. Everyone in cattle production likes to see cattle be able to get up and run, buck and play at will. In fact we use the ability to express normal behavior as the main tool in monitoring the health of the individuals within a group. Being able to determine what animals within a group that are not expressing normal behavior is paramount to the success of health management programs in pasture or confinement situations. "Pulling sick cattle" from the pasture or pen is really just pulling ones that are not acting normal.

Freedom from fear and distress is probably the most misunderstood of these five freedoms. What does this really mean, "ensuring conditions that avoid mental suffering". Most people have never really even thought about a cow having the ability to have mental suffering, much less suffer from fear or distress. Mental suffering is what the industry commonly refers to as stress.

Stress and its associated consequences represent one of if not the greatest drain on the livestock industries. Stress can be managed very effectively. However, it requires physical management. You cannot manage stress by using a product or technology to any significant extent. Products and technology may oftentimes lead to more stress on an animal rather than less. A prime example are vaccines. Although a critical asset in disease prevention the product itself puts the animal in stress. If physical stress of processing, weaning, hauling, commingling is added to by improper timing of vaccinations we can either create animals more susceptible to infection immediately and/or have no response to the vaccines and have an animal thought to be protected be susceptible to viral or bacterial infection.

Stress is created through human action and therefore must be managed through human action. Other than environmental stress caused by extremes in weather patterns all other stresses are human related. If this interface between humans and livestock is the start of the largest economic drain on the industry perhaps it is time more focus is placed back on "husbandry" than just the science and technology. The better the application of husbandry principles the greater the benefit from application of sound science and technology in animal agriculture.

There is an art to the proper care and management of livestock that has been taken for granted within the animal industries. This is one of the few industries where people are hired with little known skills or any real background in the industry and asked to manage multimillion dollar investments with no training and oftentimes little oversight. Managing the well being of animals affects the quality of life of the animal, the people involved and the profit of an operation.

Lack of employee knowledge, skills and training and inadequate oversight has resulted in several recent high profile problems in animal care and handling across most sectors of animal production. People who do not know or understand animal behavior and how to use that behavior to move or manage the animal can quickly become frustrated. Use of excessive force is often times the response to this frustration.

When it is broken down into its most simplistic form this excessive force is the result of poor training and development of the skills necessary to perform the job. Now whose fault is it that this training or development of skills has not occurred? Everyone in the industry is to blame. More specifically each individual owner or manager should be trained and be able to train employees to ensure that an adequate level of skill is developed to perform the requirements of the job.

This is an industry that prides itself on not being regulated relative to production or employment practices. If the industry does not become more proactive in these areas of employee training and oversight regulation will follow. The old saying "if you build it they will come" applies here too. If we build an environment of poor oversight in production and management governmental oversight will come.

The following is a statement gleaned from a presentation by Robert Spitze in 2009, titled **Globalized Agriculture Requires Regulation**. "Food and health are too important to be left to the unregulated private indulgences of men and nations. It is up to interested, informed citizens to help decide the desired combination of public and private policies."

Our industries cannot continue to deny that we are in the sights of activists, bureaucrats and regulators. The animal industries must do several things well in the next few years to prevent excessive and unwarranted regulation from becoming a burden. Animal production must be proactive in the aspect of making sure its own shop is clean and also in informing the citizens about the real story of food animal production. Nothing done in our industries are just done for the heck of it. Gestation crates and laying cages for example are designed so that timid sows and hens have a better chance of satisfying freedom number 1 and also to prevent problems in freedoms 2, 3, 4 and 5. Now I am not saying that there is not a need for continually monitoring and modifying current production practices to make them better. Anyone who thinks they are we know everything often time knows very little.

The general public has no concept of the aggressive and oftentimes cannibalistic tendencies of swine and poultry. They have not and will not ever witness the oftentimes slow and painful death of pigs or polts at the hand of pen/herd mates. The activist answer is always to "turn them back to their natural habitat and they will stop those aggressive behaviors." Nothing could be further from the truth but while they are turned out in the "free range" it is just harder to document these cannibalistic tendencies or the exposure to other predators. The survival rate of free range chickens is pretty low. Swine on the other hand is completely the opposite. They have few natural enemies in this country.

The same goes for the crippling and debilitating injuries inflicted on members of their own flock or herd by groups of intact males. There are reasons we do what we do but we have done a poor job communicating those reasons.

Managing for the Five Freedoms

Stockmanship, plus the training and supervision necessary to achieve required standards, are key factors in the handling and care of livestock. A management system may be acceptable in principle but without competent, diligent stockmanship the welfare of animals cannot be adequately safeguarded. The need for better awareness of welfare needs, for better training and supervision is greater than the industry realizes at this time.

There have been training opportunities for improved stockmanship for years but there have been limited participation in these trainings by producers or their employees. More focus has been on designing facilities to help manage behavior of livestock. While this focus on facilities has helped it fails miserably when not coupled with proper stockmanship training and oversight.

There are more and more opportunities to attend stockmanship trainings across the industry and there are many excellent teachers emerging in this area. It will continue to be a needed as long as there are established producers who are in need of training or new people coming into the industry. There is always a need for continuing education in these practices, as well.

The amazing thing about stockmanship is that training is available at a low or no cost to producers and the economic benefits of improved stockmanship skills is tremendous. It is one of the few things we can do in production agriculture that can increase income without increasing cost. Often times it possible to save significant dollars in facility construction and repair by improving stockmanship and facility design.

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Avoiding Calving Problems

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Beef heifers experience calving difficulty, or dystocia, more frequently than do mature cows. Dystocia is characterized by prolonged or difficult labor due to heavy birthweight and/or small pelvic area of the dam. Death of these calves, and sometimes their dams, is a result of injuries received during difficult delivery. This obviously reduces calf crop and potential profits. Cows that experience dystocia also have lower rebreeding rates than animals that have normal, unassisted deliveries. Consequently, producers should make every effort to avoid dystocia.

Causes of Dystocia

There are a number of factors that influence dystocia; fortunately most of them can be controlled through good management practices.

One factor is improper selection and development of replacement heifers. Small, underdeveloped heifers generally have a higher incidence of dystocia than properly developed heifers because they have smaller pelvic openings. Select heifers that are heaviest, and feed them to ensure proper growth (1.5 to 1.75 pounds of gain per day). At this rate of growth, the heifers should weigh betwen 65 and 70 percent of their expected mature weight by 14 months of age (first breeding). Gain during gestation should average about 1 pound per day, provided that this allows for enough fat cover, or body condition, at the time of calving.

Much research has been done to determine the effect of feed level prior to calving on the incidence of dystocia. From this research one can conclude that feed levels during gestation do not influence dystocia as much as we once thought. Excess energy during gestation is not as much of a problem as excess protein. The latter increases birthweight of the calf and the incidence of calving difficulty. Therefore, pay particular attention to the amount of protein fed to heifers during gestation. The best experiments in this subject show the need to feed a balanced ration that affords proper growth as described above. If pregnant heifers are on winter pastures (wheat, oats, ryegrass, clovers), limit grazing to 30 minutes per day rather than grazing full time. This helps avoid excess protein in the diet and its associated increase in the offspring's birthweight. In other research, efforts were made to starve dystocia out of heifers through feed restriction. The assumption in these trials was that less feed would reduce birthweight and, thus, dystocia. These efforts were futile, and this practice is not recommended since it will reduce the body condition of heifers at calving time, which is proven to reduce subsequent rebreeding rates.

As cows mature and their pelvic openings grow larger, the incidence of dystocia decreases. Knowing this, many producers calve their heifers first at 3 years of age rather than at 2 years. This helps, but never totally eliminates dystocia. Furthermore, calving heifers first at 3 years of age is not recommended because it increases the costs of production per individual animal and can reduce their total lifetime productivity.

Improper calf posture (breech, head or hoof turned back) during delivery can cause problems, but this can be corrected simply by giving assistance at birth. We know that calf posture can change, even during the early stages of delivery. The reasons for this are undetermined, and we are not able to affect calf posture except during delivery.

It is a common belief that exercising the dam during gestation can reduce dystocia. But an experiment in which heifers were forced to move and travel during gestation revealed that no advantage was gained through exercise.

The main cause of calving problems is heavy birthweight. As birthweight increases, so does the degree and intensity of dystocia, especially when heifers also have small pelvic openings.

Causes of Heavy Birthweights

Three major factors influence birthweight: 1) sex of the calf (bull calves are heavier); 2) nutrition level of the dam during gestation; and 3) the genetic influence on birthweight by the sire. Obviously, sex of the calf can not be easily controlled. Methods of doing this are currently being developed, but only for the purpose of offering the cattleman the choice of gender in his calf crop in order to increase his marketing options. Nutrition level of the dam during gestation can be controlled, but efforts to reduce dystocia through excessive nutritional restriction have been futile. The most prudent and effective way to reduce birthweight is to use a bull that is known to sire calves with light birthweights. Mating this type of bull to properly developed heifers has, in many experiments, almost entirely eliminated calving problems except those associated with improper calf posture.

Finding the Desired Bull

Some breeds have gained the reputation of being difficult calvers while others have not. This is unfortunte and unjustified because within every breed there are "easy calving" and "hard calving" bulls. Some of the breeds that have been intensively selected for growth without regard for calving ease have a higher proportion of bulls that can be characterized as hard calvers. This does not imply that these breeds no longer have any easy calving bulls, and it is unwarranted to classify any breed as hard or easy calving. Admittedly, crossing bulls of a breed with light mature weights to females of a breed with heavy mature weights may reduce the incidence of dystocia. But on the other hand, random mating of those same bulls to females of the same breed may or may not influence dystocia. Therein lies the problem. What can be done to find a sire, within any breed, that is an easy calver? The solution is to use a good set of progeny records for that breed. This kind of record program is essential to finding the easy calving bulls, and a number of breed associations have adopted these procedures. This makes it easier for the bull buyer to find the correct bull.

As a buyer, what evidence do you need to see? Look for records that show the expected progeny differences (EPDs) in birthweight for calves from the bull in question. Bulls with a low EPD (less than +5 pounds) for birthweight are the easier calving bulls in that particular breed. Most importantly, look at the bull's calving ease score. Acceptable scores are further evidence that the bull in question is an easy calver.

Most of the breeds which have selected their cattle for performance likely have several sires with records on a high number of offspring. As the number of offspring from a sire increases, the accuracy of his predicted performance increases. Thus, look for accuracy figures in the performance data. These figures are given in fractions such as 0.5 up to 1.0. The higher the accuracy figures the more predictable the bull's performance. A low accuracy figure for any trait means that the bull has not yet produced enough offspring to accurately predict his performance.

When dealing with breeds that do not utilize performance records, it is very difficult to predict the performance of a sire for any trait. People who sell bulls should supply their buyers with performance data. This helps assure the buyer that he is getting the product he wants, and assures the seller of a repeat customer.

Summary

The best way to avoid calving problems is to choose the heaviest heifers as replacements, grow them to an acceptable weight and mate them to an easy calving bull. This approach will be successful in reducing dystocia except in those instances involving improper calf posture. Since the incidence of posture problems is low, dystocia attributed to excess birthweights and small pelvic openings can be almost entirely eliminated.

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Breeding Soundness of Bulls

L.R. Sprott, T.A. Thrift and B.B. Carpenter*

The importance of the bull in a cattle breeding program often is underestimated. A cow is responsible for half the genetic material in only one calf each year, while the bull is responsible for half the genetic material in 20 to 50 calves. The bull's ability to locate cows in estrus and breed them is clearly vital to a successful breeding program.

Bulls differ in physical appearance, fertility and sex drive (libido). In the past, when a cow failed to become pregnant it was assumed that she was at fault. Occasionally, that is true. However, a clear understanding of the male reproductive system and the differences between reproductive capabilities of bulls indicates that the cow is not always at fault.

Reproductive System

One of the major organs of the bull's reproductive system, the testis (or testicle), is made up of two tissues that perform different functions. The seminiferous tubules produce sperm, while the Leydig cells (interstitial tissue) produce tes-tosterone. The testes should be free and not adhering to the inside of the scrotum. A minor twist in the scrotum resulting in a slightly sideways suspension of the testicles may not affect reproductive performance but is abnormal in conformation and visually unpleasing. A major twist may indicate structural defect and reduced fertility.

The scrotum supports and encloses the testes. Its main function is to regulate testicular temperature. It does so through perspiration and by muscular contraction that raises the testicles in cold weather and relaxation that lowers them during warm weather.

Inside the scrotum (Fig. 1) and adjacent to each testicle is the epididymis, a 10- to 12-foot long, tightly coiled tube made up of three sections (head, body and tail). The functions of the epididymis are concentration (from 100 million/cc to 4 billion/cc), storage, maturation and transportation of sperm cells. Immature sperm cells are immobile when they enter the epididymis, but become mobile after maturation. Their ability to fertilize an egg requires a period of retention in the female reproductive tract after mating, and exposure to certain compounds contained there.

The vas deferens extend from the epididymis to the ampullae. They aid in transport of sperm cells. Prior to ejaculation, sperm cells are pooled in the ampullae. The seminal vesicles and prostate gland contribute volume to the ejaculate by secreting fluid that contains substrates, buffers, inorganic ions (sodium, chlorine, calcium, etc.) and proteins. These proteins (known as fertility associated antigens) are particularly important since they bind to certain compounds in the female tract that increase the chances of fertilization. At ejaculation, the semen is transported via the urethra and through the penis.

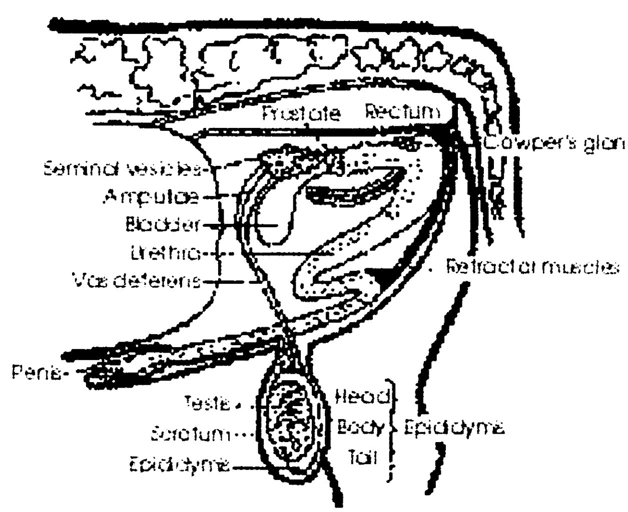

Figure 1. The reproductive tract of the bull.

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Breeding Soundness Evaluation

Bulls should be evaluated for breeding soundness 30 to 60 days before the start of breeding to allow sufficient time to replace questionable bulls. Bulls should also be evaluated at the end of breeding to determine if their fertility decreased. This second evaluation may explain a low calf crop percentage.

A breeding soundness evaluation (BSE) is administered by a veterinarian and includes a physical examination (feet, legs, eyes, teeth, flesh cover, scrotal size and shape), an internal and external examination of the reproductive tract, and semen evaluation for sperm cell motility and normality. Libido is not included in a BSE; it must be measured through visual observation during mating activity.

Physical Examination

Part of the physical examination involves the overall appearance of the bull. Flesh cover (body condition) is one factor to evaluate. Body condition can vary by breed, length of the breeding season, grazing and supplemental feeding conditions, number of cows the bull is expected to service, and distance required to travel during breeding. A thin bull may not have the stamina needed to service many cows in a short period on extensive range conditions (large acreage). An overly fat bull may lack vigor and not be able to breed up to his potential. Excessively thin bulls and fat bulls usually have low quality sperm. Ideally, bulls should have enough fat cover at the start of breeding so their ribs appear smooth across the animal's sides.

Sound feet and legs are very important. Bulls with structural unsoundness such as sickle hocks, post legs, and bent or knock knees may develop soreness. The result is the inability to travel and mount for mating. Long hooves and corns between the hooves result in similar problems.

Eyes should be clear and injury free. The teeth are checked for excess wear or loss. The general health of the bull is critical since sick, aged and injured bulls are less likely to mate and usually have lower semen quality.

Examination of the Reproductive Tract

An internal (rectal exam) and external examination should be conducted. The rectal exam is to detect any abnormalities in the seminal vesicles, prostate, ampullae and the internal inguinal rings. Rarely are there any problems with the prostate, but an infection can occur in the seminal vesicles leading to a condition called seminal vesiculitis. This is not an unusual condition in bulls and is characterized by enlargement of the seminal vesicles. Rarely are there complications with the ampullae, but the inguinal rings are examined for indications of hernia. Major herniation can also be observed externally. The latter is characterized by abnormal enlargement of the scrotum and manual palpation of intestinal loops within the scrotum.

The external examination of the reproductive tract includes manual palpation of the testes, spermatic cords and epididymis. The testes should feel firm, while the upper portion of the epididymis should feel soft and free of any lumps or enlargements.

Degeneration of the testes may occur at any time and can be caused by prolonged hot weather with high humidity, poor blood circulation, age, trauma, stress, bacterial diseases of the testes and genetic susceptibility. A general sign of degeneration is a decrease in testicular size. Maintaining records of annual BSE results for each bull will help detect changes in testicular size.

Scrotal circumference is an important measure since it is directly related to the total mass of sperm producing tissue, sperm cell normality, and the onset of puberty in the bull and his female offspring. Bulls with large circumference will produce more sperm with higher normality. They also reach sexual maturity sooner, as do their daughters. Table 1 shows average scrotal circumference of various beef breeds.

Examination of the penis and prepuce will detect inflammation, prepucial adhesions, warts, abscesses and penile deviations. The erect penis should be parallel to the bull's body.

Semen Evaluation

During a BSE, bulls will be electroejaculated and their semen should be microscopically evaluated for sperm cell motility and normality. Unless there is an obvious lack of sperm cells in the sample, cell concentration in the sample may not be very informative, as some bulls do not always respond well to electrical stimulus. Even then, it is wise to collect semen a second time to confirm if concentration is low. Sperm cell motility and normality are not necessarily

Table 1. Comparison by age of average scrotal circumference (cm) of beef breeds.

Breed	Months <14	14-17	18-20	21-23	24-26	27-30	31-36	>36
Angus	34.8	35.9	36.6	36.9	36.7	36.3	36.6	38.2
Charolais	32.6	35.4	34.5	34.9	34.6	36.2	37.1	38.1
Horned Hereford	33.0	32.2	34.1	36.2	33.4	33.8	35.2	34.0
Polled Hereford	34.8	34.2	34.9	34.9	34.8	35.0	35.6	36.4
Simmental	33.4	36.5	—	—	36.0	—	—	37.2
Limousin	30.6	31.7	32.0	33.9	—	—	—	35.5
Santa Gertrudis	34.0	35.3	35.5	36.7	36.5	36.4	38.3	40.5
Brahman	21.9	27.4	29.4	31.4	31.7	33.5	34.7	36.7

affected by electroejaculation and can easily be assessed during examination. They are the most important characteristics because a high number of moving, normal sperm cells are required for fertilization of an egg.

The criteria for scoring on a BSE are shown in Table 2. Any bull meeting all minimum standards for the physical exam, scrotal size (varies by age and breed), and semen quality will be classed as a satisfactory potential breeder. Bulls that fail any minimum standard will be given a rating of "classification deferred." This rating indicates that the bull will need another test to confirm status. Mature bulls should be retested after 6 weeks. Should they fail subsequent tests, mature bulls will be classed as unsatisfactory potential breeders.

Young bulls rated as classification deferred may not have reached sexual maturity and should be retested at monthly intervals until puberty is confirmed. It should be remembered that, even though accurate, a BSE is nothing more than a snapshot of a bull's breeding potential at that point in time. Since a bull's physical condition and sperm quality can change, a BSE should be done on all bulls annually prior to the start of breeding.

Table 2. Scoring criteria for a BSE.

Minimum sperm motility - 30%

Minimum sperm normality - 70%

Minimum scrotal circumference (by age)

Age (months)	Circumference (cm)
15 or younger	30
16-18	31
19-21	32
22-24	33
25 or older	34

Physical exam

- Must have adequate body condition and sound feet, legs and eyes.
- Must have no abnormalities in:
  - seminal vesicles
  - ampullae
  - prostate
  - inguinal rings
  - penis
  - prepuce
  - testicles
  - spermatic cord
  - epididymis
  - scrotum (shape & content)

Adapted from Society of Theriogenology (1992).

Libido and Ability to Mate

Libido is, of course, a precursor to the ability to mate, but some bulls (10 to 35 percent) can not mate even though they have high libido. Injury, lameness, illness, and penile abnormalities may prevent bulls from accomplishing the act of mating. There is also evidence that libido and mating ability are genetically influenced.

Libido and the ability to mate are not measured during a BSE and can only be assessed by observing bulls in the presence of females. The number of mounts and services accomplished by the bull in a given period of time are recorded. Based on a scoring system, bulls are classed as having either high, moderate or low serving capacity. High serving capacity bulls are the most desirable because they settle more cows in fewer days than do moderate and low bulls. Whether formal tests for serving capacity are performed or not, producers are encouraged to observe their bulls during the breeding period to detect any bulls not performing their duties.

Unfortunately, libido and serving capacity are not related to BSE results or visual estimates of masculinity (thickness of the neck, muscle definition, coarseness of hair). Testosterone levels in the blood are slightly related, but only to a minimum threshold. Bulls with testosterone levels beyond this threshold are not necessarily good breeders.

Nutrition

Nutrition is important during the development of a young bull's reproductive system. Improved levels of nutrition will hasten puberty and body development. Extremely high levels of nutrition may lower libido and magnify structural weakness.

Underfeeding for prolonged periods will delay puberty and cause irreversible testicular damage. If a mature bull is subjected to prolonged underfeeding, sperm quality and libido will decrease. Overfeeding of mature bulls may result in similar problems, but adjustments in feed levels may reverse the situation. Approximate nutrient requirements for growing and mature bulls are shown in Table 3.

Genetic Factors Affecting Fertility

The onset of puberty, libido and serving capacity are influenced by genetics. There are differences both between and within breeds. Recent work regarding the presence of fertility associated antigens in sperm (see "Reproduction System") also indicates a degree of genetic control.

Generally, *Bos taurus* breeds mature at an earlier age than *Bos indicus*. Crossbreeds of these two will reach puberty at some age between their parent breeds. Other research indicates that earlier maturity in any breed can be accomplished by selection for increased yearling scrotal circumference.

Table 3. Approximate nutrient requirements for bulls.

Body weight	Gain	TDN	Total protein	Ca	P
600	2.5	73.5%	11.4%	.46%	.24%
700	2.5	73.5%	10.5%	.40%	.22%
800	2.0	67.5%	9.2%	.31%	.20%
900	1.5	63.0%	8.4%	.25%	.19%
1000	1.5	63.0%	8.1%	.24%	.19%
1100	1.5	61.0%	8.1%	.24%	.19%
1300	1.5	56.0%	7.6%	.22%	.19%
1500	1.5	56.0%	7.4%	.21%	.19%
1700	0	48.0%	6.8%	.21%	.21%
1900	0	48.0%	6.8%	.21%	.21%
2200	0	48.0%	6.8%	.22%	.22%

From National Research Council, 1984. Nutrient requirements of beef cattle.

In summary, many producers work hard to manage their cows for high fertility. They may assume that the bulls will do their expected duties, but thorough fertility management also includes attention to the bulls.

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Soil & Crop Sciences

Managing for High Quality Hay

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Hay is the most common source of stored feed used in livestock operations. Surveys show that 86% of the harvested hay is used on the producer's own farm; therefore, producers should be concerned with producing quality hay. Hay harvested at the proper stage of plant growth and undamaged by weather provides nutrients at a minimal cost compared to other high quality supplemental feeds. Forage varies greatly in quality and it should be remembered that high quality or low quality forage can be produced from most forage species. Legumes such as alfalfa and clovers, generally contain a higher percentage of protein, minerals and vitamins than grasses. However, grasses usually produce higher forage yields and higher amounts of total digestible nutrients per acre than legumes. Insects, disease and harvest problems are fewer on grasses than legumes and grasses require fewer production inputs. Regardless of the forage, quality hay production requires special attention to details and constant management.

The range of quality varies greatly based on climate, fertility, weed control, stage of maturity at harvest, harvest conditions and storage. Forages of almost every kind are preserved as hay for livestock feed, yet much of it is poor quality and fails to provide the nutrition needed. Low quality hay requires extra supplementation to meet animal requirements.

High quality hay is palatable dry forage, highly digestible, with sufficient nutrients to meet the nutritional needs of the class of livestock to which it is being fed. High quality hay requires a minimum of or no additional supplementation, is bailed at a moisture level to prevent spoilage yet moist enough to prevent shattering losses, and is free of foreign matter, weeds and molds. Determination of high quality hay is a combination of both physical factors and the nutritional status.

Factors That Determine Hay Quality

Factors that determine hay quality include stage of maturity at harvest, soil fertility, nutritional status of the plant, available moisture during the growing season, season of the year, ratio of leaves to stems and stem size, weed control, foreign matter, and harvesting, weather at harvest and storage. Of all the factors that influence quality, stage of maturity or age of the plant at harvest is the most important. About 70% of the quality of hay is determined by stage of maturity at harvest. As a plant matures toward heading, flowering and seed formation, the growth pattern changes from leaf production to hard stem formation. The digestible portion of the plant tissue decreases rapidly with each stage. Maturity effects the ratio of digestible leaves to indigestible stems which determines both the nutritive content and digestibility of forages. A 1% increase in digestibility of a warm season forage results in a 5% increase in animal performance.

Immature plants cells have a thin primary cell wall and are succulent with soft flexible tissue that is high in water and water soluble nutrients. Immature leafy forage plants contain easily digestible nutrients while old, mature stems and leaves contain complex nutrients and mature indigestible fiber. As plants begin to form seed, cells mature and a secondary wall composed of cellulose and lignin begins to develop to add rigidity to the plant. Lignin is indigestible and is comparable to wood. For example, Coastal bermudagrass, which is 12 inches tall can be 58% digestible in the top third of the plant, 54% digestible in the middle third, and only 50% digestible in the bottom third. Coastal bermudagrass harvested at 6 weeks of age has only 50% of the crude protein content and 80% of the energy of hay harvested at 4 weeks of age.

Since leaves are more digestible than stems and contain most of the nutrients, the higher the leaf content, the higher the quality. Additionally, seed heads are usually produced on the end of stems which are devoid of leaves, decreasing the leaf to stem ratios. To determine the maturity, look for seed heads. As a guide, grass hays with only a few immature seed heads is high quality, however, as the number and amount of mature seed in the heads increase, the quality decreases.

The proper stage of growth for harvesting forages is the time when the greatest amount of total digestible nutrients per acre may be obtained. This usually represents the best compromise between quality and yield. Generally, the younger the crop at the time of harvest, the higher the quality but the lower the yield. The more mature the crop at time of harvest, the higher the yield but the lower the quality. Crude protein content drops in all crops and crude fiber increases with maturity as shown in Table 1 and 2.

Research also indicates that forages are higher in quality during spring and fall and lower in quality during mid-summer. Hence hay harvested during the spring will tend to be higher in forage quality than hay harvested in July and August.

Table 1.

Forage	Stage of Growth	% Crude Protetin	% Crude Fiber
Alfalfa	Early bloom Full bloom	19.3 16.9	27.3 31.7
Coastal Bermudagrass	3 week growth 7-8 weeks growth	18.3 6.7	24.2 25.5
Oats	Pre-boot Early bloom	27.6 15.3	19.8 28.0
Sudangrass	Early boot Early bloom	16.8 8.1	30.9 36.4
Johnsongrass	Early boot Half bloom Mature seed	15.0 8.6 5.6	31.2 36.0 37.9

Table 2

Clipping Frequency (weeks)	Yield/Acre (tons)	Percent Crude Protein	Percent Leaf	Percent Stem	Percent Fiber	Invetro Dry Matter Digestibility
3	7.9	18.5	83	17	27.0	65.2
4	8.4	16.4	79	21	29.1	61.9
5	9.2	15.4	70	30	30.6	59.3
6	10.3	13.3	62	38	31.6	58.0
8	10.2	10.7	56	44	32.9	54.1
12	10.4	9.0	51	49	33.4	51.0

Fertility and Water Interaction

Nitrogen content of a forage is a direct measure of its protein content. The nitrogen that is extracted from a forage is multiplied by a factor of 6.25 and reported as percent crude protein. Thus, a forage containing 2 percent nitrogen contains 12.50 percent crude protein. Nitrogen fertility rates for grasses then greatly influences the crude protein levels in forages harvested at the right stage of maturity. Table 3 indicates the pounds of nitrogen contained in dried forages at different production levels.

Table 3. Pounds of Nitrogen Contained in Forages

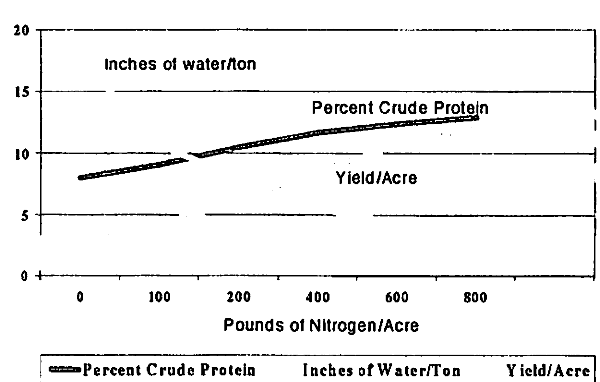
% Nitrogen	% Crude Protein	1 Ton/ Acre	2 Tons/ Acre	3 Tons/ Acre	4 Tons/ Acre	6 Tons/ Acre
1.0	6.3	20	40	60	80	120
1.3	8.1	26	52	78	104	156
1.6	10	32	64	96	128	192
2.0	12.5	40	80	120	160	240
3.0	18.8	60	120	180	240	360
4.0	25.0	80	160	240	320	480

Since most nutrients are absorbed by roots when dissolved in water, the uptake of nitrogen and other nutrients is dependent on the moisture status in the soil. When nitrogen is absorbed with adequate water, new plant proteins and cell formation create growth. Without adequate nitrogen levels, grasses continue to pick up water which evaporates through the leaves, but new growth is not produced.

For the best combination of yield and quality without contributing to excess N in runoff or groundwater, N rates should be adjusted to the yield potential. The following chart developed from research near Crystal City, Texas shows the relationship between nitrogen, quality and water use efficiency.

Effects of Nitrogen Rates

Percent Protein, Yield and Inches of Water/Ton



Phosphorus, potassium and other nutrients are also critical to maintaining stands and producing quality hay. A soil test should be taken once a year to determine the amount of plant nutrients remaining after the previous years productions to replace those elements removed by harvest.

The nutrients in one ton of forage is approximately 50 pounds of nitrogen, 15 pounds of phosphorus and 40 pounds of potassium. (See bulletin No. B-6035 Crop Nutrient Needs for South and Southwest Texas for additional fertility information.) If three tons of forage are removed annually in the form of hay, it will equal approximately a total of 150-45-120 pounds of nutrients removed.

High yielding production removes other nutrients as well. Soils in hay fields should be periodically sampled to determine the levels of pH (Table 4), sulfur, calcium, zinc, iron, etc. If the nutrient levels in the soil are dropping, they should be replaced as needed. Generally, nutrients other than nitrogen can be applied once per year.

Table 4. **Effect of soil pH on relative efficiency of nutrient uptake**

Soil pH	Nitrogen	Phosphorus	Potassium
4.5	21	8	21
5.0	38	10	30
5.5	52	15	45
6.0	63	15	60
7.0	70	30	60

Harvesting

The goal of harvesting should be to maintain the highest nutritive quality as possible through cutting at the proper stage of maturity, promoting rapid drydown, maintaining high leaf content and timely baling at the right moisture content. Since living cells continue to respire and use energy, hay should be managed to dry the forage to below 40% as rapidly as possible. Most plants are almost 80% water and continue to metabolize cellular carbohydrates and sugars until the moisture levels in the forage reach 40%. Tight windrows, moist soil and cloudy, high humidity conditions all delay drying and promote valuable energy losses.

Recent experiments (USDA) indicate that cattle prefer afternoon cut hay over morning cut hay. Since cells make sugars and carbohydrates in the presence of sunlight, afternoon cut hay may contain a higher percentage of highly digestible sugars and carbohydrates. Plants cut in the morning have partially depleted the supply while respiring or using energy through the night.

Harvesting practices that increase hay quality include cutting in the afternoon, laying hay down on dry ground or stubble to prevent soil moisture from rising into the windrow, raking operations that do not cause leaf loss and baling at the right moisture.

Bacteria and fungi that cause hay to deteriorate, need moisture to grow. If hay is baled at a too high moisture, bale heating occurs shortly after harvest. Microbes are not able to reproduce if moisture levels are below about 14%. Small bales are often referred to as needing to go through a "sweat" in the field prior to stacking. The "sweat" is an additional loss of moisture if the hay was baled too "green". Small 60-70 pound bales can be baled at 16-18% moisture. Hay stored in large round bales need to be dryer (14-16%) at baling since moisture is unable to escape from the center of a large bale.

Quality Losses

Growing high quality forages is only a part of producing high quality hay. Poor harvesting can result in as much as a 50% loss on digestible nutrients. Cutting forages past the optimum stage of maturity, rain leaching soluble nutrients (highly digestible nutrients) out of the cutting forages and prior to baling, respiration of plant tissues and leaf shattering from overly dry forages.

The biggest losses to quality are caused by delaying harvest from the optimum developmental stage. Alfalfa's digestibility declines 0.5% per day following flowering while Coastal bermudagrass digestibility declines 0.2% per day from 4-8 weeks of age.

The most highly digestible nutrients in plants are water soluble cell contents. The younger (immature, succulent) the plants, the more water soluble nutrients they contain, the older (more mature) the plants, the less water soluble nutrients they contain. Rain on cut forages causes nutrients to leach out of the plant cells and increase dry matter losses. The greater the amount of both the time the forage is wet and amount of rain after cutting washing through the hay, the greater the nutrient losses. In a Purdue University study, 1-inch of rain reduced the TDN content of field-cured hay 5% while dry matter losses from wind dried hay were 3.5% per inch of rain. In general, leaching losses are less for a fast short duration 1-inch rain than a slow soaking rain of the same amount. Losses are higher from dry forage than fresh cut forage.

Plant cells are living tissue that will continue to respire (burn energy) even after cutting. Cutting a plant off does not stop the tissue from continuing to live for a period of time. Drying causes the cells to die. When moisture drops below 40%, cell activity stops. Poor drying conditions allow continued respiration of readily digestible carbohydrates (energy) which can result in a 10-15% loss of the original dry matter. Coastal bermudagrass (Overton Experiment Station) changed from 11.1% crude protein and 51.6% TDN at cutting to 8.9% crude protein and 42% TDN at baling after two days of drying.

As hay dries, the leaves become brittle and may break apart or fall off the plant. Alfalfa's leaves are attached very delicately to the stems and are particularly prone to leaf loss when raked too often or when too dry. Raking losses can amount to 5-15% and poor baling practices can result in an additional 1-15% loss.

Storage Losses

The amount of storage losses are directly related to the moisture to which the hay is subjected. Hay that is baled at too high moisture will develop mold and bacterial degradation or even in extreme cases, catch fire. Moldy hay can cause digestion problems in livestock. As the hay is "digested" by microbes, dry matter losses occur. Hay should be kept ***dry***. Round bales stacked outside on wet soil will lose as much as 25% of its original weight in one year.

Summary

Close attention to all aspects of hay production will result in production of high quality and quantities of livestock feed.

ABC's of Forage Testing

NDF **Neutral Detergent Fiber** is a test that uses water to dissolve highly soluble components such as sugars and carbohydrates and proteins from the forage. NDF is a measure of the structural fiber in the plant. It is an excellent predictor of consumption.

ADF **Acid Detergent Fiber** is a measure of cellulose, lignin, silica, insoluble crude protein, and ash, which are the least digestible parts of the plant.

CF **Crude Fiber** is a measure of total plant fiber.

CP **Crude Protein** is an estimate of the amino acids/proteins in a hay/feed based on the total N in the material.

DP **Digestible Protein** is an estimate of the animal available crude protein.

DM **Dry Matter** is an oven dried weight or 0% moisture.

DDM **Digestible Dry Matter** is the percentage of digestible dry matter

TDN **Total Digestible Nutrients** is an estimate of the percent of total digestible nutrients. It is based on ADF of the quantity of available nutrients in the forage.

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Forages for Beef Cattle

David Bade and Donald J. Dorsett*

Pasture forages for beef cattle can be roughly divided into five categories—warm-season perennials, warm-season annuals, cool-season perennials, cool-season annuals and legumes for pastures. Each of these forage types can meet the nutritional requirements of beef cattle when they are at their peak production (Figure 1). However, none are able to satisfy the nutritional needs of a cow with calf or a growing animal, which are at their low point in production.

Warm-Season Perennials

Warm-season perennial pastures tend to be the best grasses for a cow-calf operation because they do not have to be planted each year. Once established, these pastures continue to produce for many years. The annual grasses are the most expensive grasses for forage because they must be planted each year, the seed is costly, there is a limited production season and they require high rates of fertilizer.

Warm-season perennial pastures, such as bermudagrass, bahiagrass or kleingrass, generally have a longer growing season than cool-season plants. Since they are perennial plants, they regrow from roots each year. Because they do not have to re-establish yearly, they maintain top forage production for longer periods. They also tend to be lower in digestibility and in protein because of the fiber buildup during the warmer part of the growing season.

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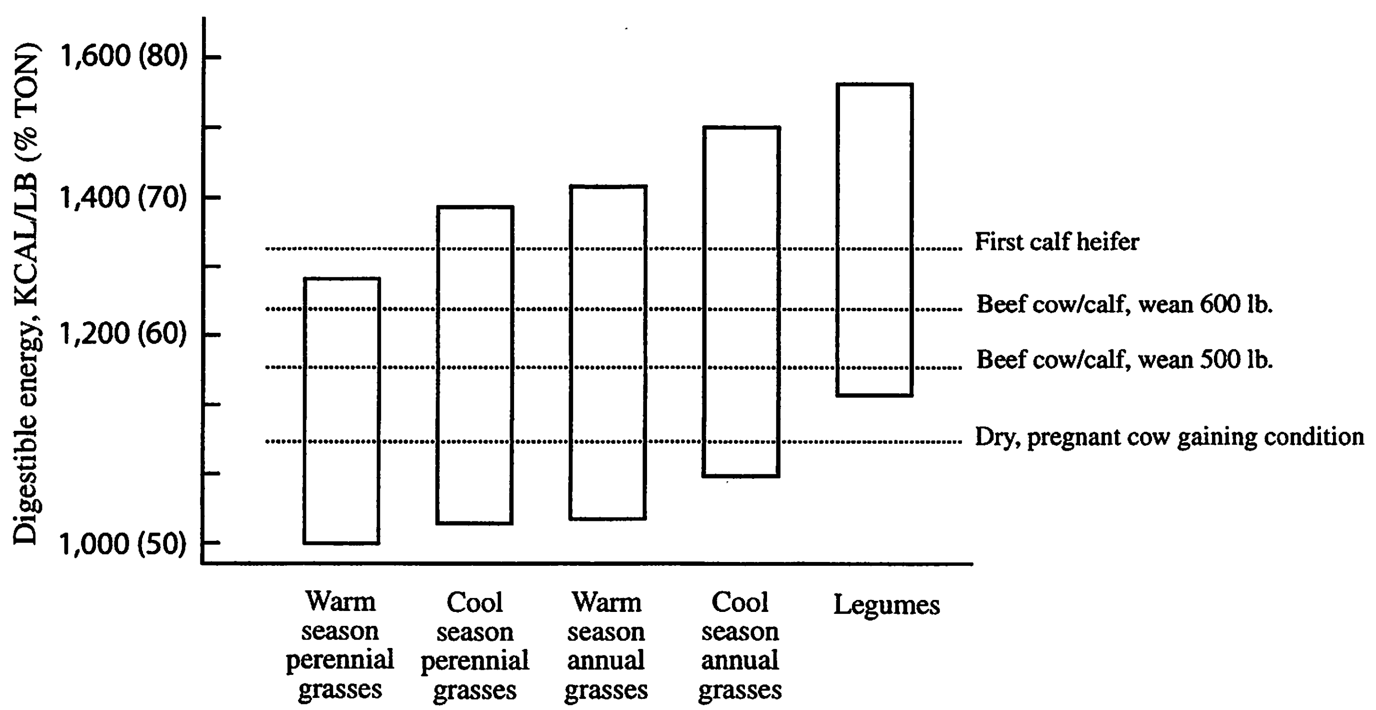

Figure 1. Variation in energy content of various forages relative to the requirements of various classes of cattle.

Warm-season perennial grasses respond well to fertilization and, with heavy fertilization, can produce large amounts of hay or grazing per acre. If fertilized and managed properly, they work well in almost any livestock production program.

Warm-Season Annuals

Warm-seasoned annual grasses, such as the sudans or forage sorghums, play definite roles in livestock production. Being annual plants, they are expensive because land must be prepared and seeded annually. They offer higher quality (digestibility) grazing than perennial warm-season plants, but their production period is shorter. They use less fertilizer, will serve as temporary pasture and maintain a relatively high carrying capacity of two or three animals per acre for 30- to 45-day periods. Their prime role in forage production, however, is for high quality hay.

Cool-Season Perennials

Cool-season perennial plants have limited use in Texas. Tall fescue and tall wheatgrass are the only cool-season perennial plants that adapt to Texas climate. They generally do not offer high quality nutrition for maximum animal performance.

Cool-Season Annuals

Although cool-season annual plants, such as oats, wheat, rye, barley, triticale and ryegrass, are expensive pastures because of the cost to establish each year, they are high in nutritional value. Winter annuals are best adapted to stocker operations or to cow-calf combination programs. Because of their expense, annual pastures may not be the best types of pastures for dry pregnant cows, which can be maintained very well on less expensive forages such as high quality hay.

Legumes

Legume forages might also be considered for a livestock operation. Temperate legumes include clovers, medics, peas, vetch and alfalfa. They can be overseeded into permanent pastures or seeded with winter annual pastures. Legumes have the unique ability to fix their own nitrogen if they are properly inoculated (nitrogen-fixing bacteria is added to the legume seed before planting). They require high levels of phosphorus, potassium and, in acid soil, lime. Cool-season or temperate legumes produce most of their growth during the late winter-spring period, when they are very useful in beef cattle operations. Warm-season or tropical legumes, such as cowpea, soybean, and peanut, can provide high quality forage during the summer. However, they are used as a salvage crop in drought years when they do not "yield" well as a row-crop.

A Year-round Forage System

No grass meets the production and quality requirements of livestock year-round. Consequently, livestock producers can benefit by combining two or more forage plants into a forage system. By growing adapted summer and winter forage species, livestock producers can furnish grazing for most of the year. Although this requires management and planning, it reduces hay and feed costs.

Sodseeding or overseeding legumes or small grains in conjunction with a warm-season perennial pasture offers several advantages over clean-tilled or prepared seedbed cool-season pastures:

- Sodseeding allows a longer productive period for any given acre of ground. The cool-season grass may not be as productive as on a clean-tilled seedbed, but using with a warm-season perennial plant, the sodseeded pastures will extend the spring green-grazing period by as much as 60 days.
- If winter pastures are adequately fertilized, the base grass or warm-season grass also benefits.
- Sodseeded pastures offer a higher level of nutrition and enhance animal performance.

Any warm-season perennial grass (bermudagrass, bahiagrass, kleingrass or even native grasses) can be overseeded. The problem is competition in late spring between an overseeded pasture and a warm season perennial pasture that is beginning to grow. There is direct, heavy competition in this overlap growth period for nutrients, moisture and sunlight. During dry springs, an overseeded winter pasture takes the elements for growth and might completely retard the growth of a warm-season grass. Heavy competition with the warm-season grasses may result in a thinning of native or bunch grass stands when they are continually overseeded.

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Supplementation Strategies for Beef Cattle

Ted McCollum III*

Supplementing nutrients to cattle—as concentrated feeds, harvested forages, or a complementary grazing program—accounts for a significant portion of annual production costs in a cattle operation. To optimize productivity of today's cattle operations, some supplemental nutrients will be required at critical periods during the annual production cycle. However, producers need to avoid unnecessarily compounding this cost by feeding too much, too little, or using range and pasture forages inefficiently. A producer should provide supplemental nutrients with minimal feed inputs. A primary objective is to use forage efficiently.

The current situation

An important aspect of selecting a supplement is knowing how it affects daily forage intake. In many situations, the success or failure of a supplemental feeding program hinges on this factor. Three common situations (Figure 1) include:

Situation 1

Cattle performance fails to meet production goals. Perhaps cows are not regaining condition as needed, or stocker calves and replacement heifers are gaining weight too slowly.

Forage availability is not limiting intake, but its quality (in many instances, its protein content) is limiting intake, and possibly forage digestion. As a result, daily energy and protein intake are below daily requirements. To improve cattle performance, select a supplement that will stimulate forage intake and digestion (see top chart in Figure 1).

Situation 2

Again, cattle performance falls short of production goals. Forage availability may or may not be limiting forage intake. Instead, production goals are simply higher than can be achieved from the forage resource. First, consider a supplement that will sustain forage intake and digestion at the present level (to assure efficient forage utilization) but provide the additional nutrients required to increase performance (see middle chart in Figure 1). If this approach does not improve performance as needed, it may be necessary to feed more supplement and sacrifice some efficiency of forage utilization.

Situation 3

In this situation, forage and energy intake are currently sufficient to meet production goals. However, due to climate or management needs, future forage supplies will be limited. A precipitation shortage may limit forage supply for fall and winter. Or, because of purchasing opportunities, large numbers of stocker cattle may be bought in late summer and fall before the rapid spring growth period for cool-season annual forages. Both can result in higher forage requirements than forage supply. A supplemental feeding program to reduce forage intake but maintain total energy intake may be desirable (see bottom chart in Figure 1).

The key to success in these three situations is to stimulate,

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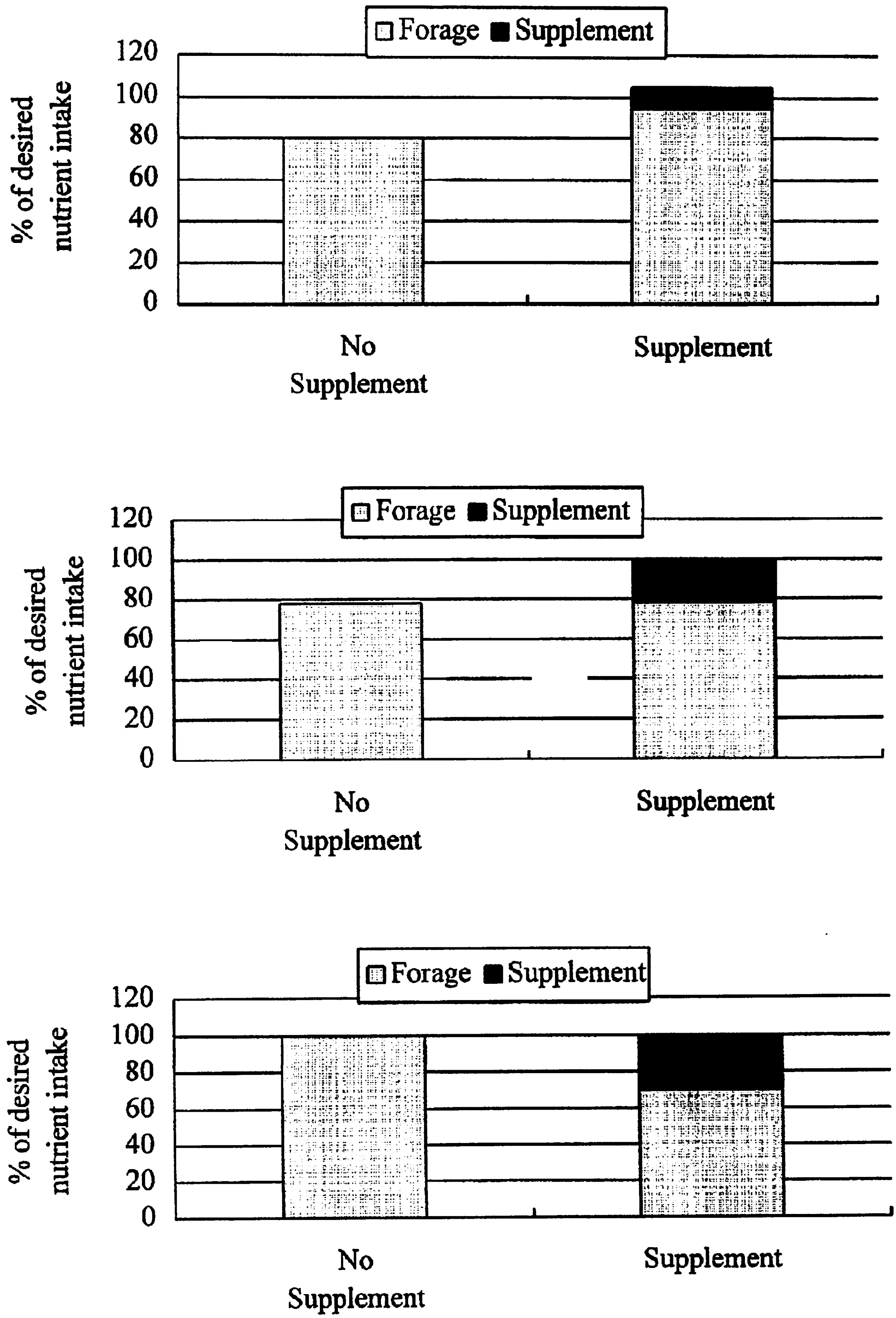

Figure 1. Three possible situations encountered in a supplementation program. Top: Increasing forage intake and energy intake with low level supplementation; Middle: Increasing energy intake while maintaining forage intake; Bottom: Maintaining energy intake while depressing forage intake.

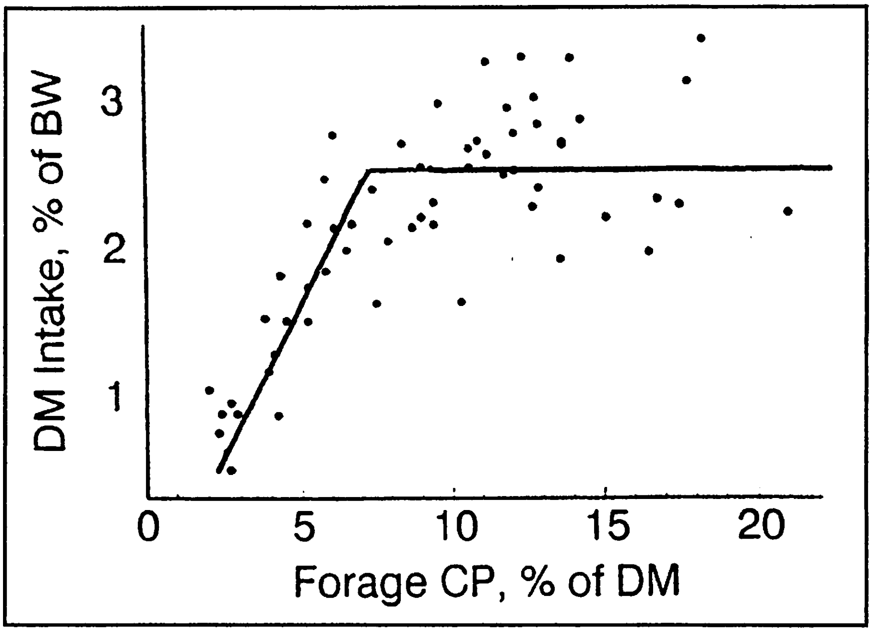

Figure 2. Forage intake in relation to crude protein concentration in the forage (Adapted from Moore and Kunkle, 1994).

maintain, or reduce forage intake. The supplemental feeding strategy required for each is different.

Forage intake and diet crude protein

Ruminal requirements

Microbial fermentation in the rumen supplies most of the energy and protein metabolized by cattle. As in the host animal, microbes in the rumen require a balanced supply of energy and nitrogen to function efficiently. The National Research Council (1984) proposed that ruminal microbes can synthesize about 113 grams of bacterial crude protein from 1 kilogram of Total Digestible Nutrients (TDN) (0.11 pound of bacterial crude protein per 1 pound of TDN). An imbalance of nitrogen and energy in the rumen can result in reduced microbial protein production, reduced forage digestion, and an unrecoverable loss of nutrients. Coupled with an unbalanced supply of metabolizable nutrients for the animal tissues, these changes can lower forage intake and cattle performance. Providing a balanced, or in some instances, unbalanced, supply of nutrients to the rumen is a key to obtaining the desired intake and production response.

Forage intake

Daily energy intake is the primary factor limiting cattle performance on forage diets. In many instances with warm-season perennial forages and possibly cool-season perennial forages at advanced stages of maturity, an inadequate supply of crude protein in the forage further limits energy intake. An example of the relationship between crude protein content of forages and forage intake is presented in Figure 2 (adapted from Moore and Kunkle, 1994). Intake declines rapidly as forage crude protein falls below about 7 to 8 percent, a relationship attributed to a deficiency of protein in the rumen.

If a forage contains less than 7 to 8 percent crude protein, feeding a protein supplement will improve energy and protein status of cattle by improving forage digestibility and forage intake. For example, in Figure 1, at a crude protein content of 5 percent, forage intake is about 1.6 percent of body weight, while at 7 to 8 percent crude protein, forage intake is 2.3 percent of body weight, or 44 percent higher. Kansas State University researchers recently concluded that various protein supplements increased forage intake on average 36 percent. When high protein (greater than

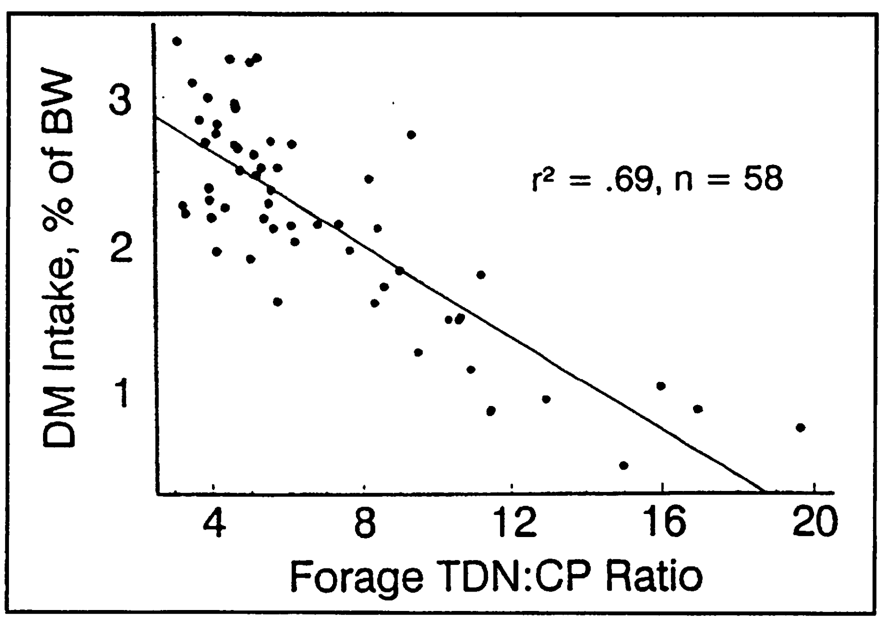

Figure 3. Forage intake in relation to the ration of TDN:crude protein in the forage (Moore and Kunkle, 1994).

30 percent crude protein) supplements were used, response varied from about 30 to 60 percent.

Improved forage intake boosts energy intake and demonstrates why correcting a protein deficiency is usually the first supplementation priority. For example, in Table 1, the estimated impact of protein supplementation on energy status is shown. Forage intake was increased 30 percent in response to a modest amount (0.18 percent of body weight) of protein supplement, resulting in a 49 percent increase in TDN intake by the cow.

Crude protein content of some forages must drop to about 5 percent before intake declines. Intake of some forages declines when crude protein is as high as 10 percent. Part of the variation can be attributed to differences in nutrient requirements of the cattle used in the research, with the remainder attributed to inherent differences among forages, which present differing proportions of nutrients to rumen microbes. Response of intake to a single nutrient such as crude protein would not be expected to be similar among all forages.

Ruminal microbes need a balanced supply of energy and protein. Figure 2 shows how to evaluate the balance of energy and protein in forages. In this case, the percentage digestible organic matter (DOM; representing available energy) is ratioed against the percentage crude protein (CP). Theoretically, ruminal microbes require a ratio around 4:1. As the DOM:CP ratio becomes larger, the amount of energy available to microbes exceeds the amount of available protein and limits microbial activity. Forage intake is negatively related to the DOM:CP ratio. Some researchers now suggest a ratio of 6:1 to 8:1 as a threshold value. If a forage has a higher ratio, supplemental protein may be needed. If the ratio is lower, the rumen is in balance or may require additional energy.

In Table 2 the dormant forage has a TDN content of 45 percent and crude protein content of 5 percent, a DOM:CP ratio of 9:1. To increase forage intake, the supplement should shift the ratio toward 6:1. Use a supplement with a relatively low DOM:CP ratio. Cottonseed meal or another protein concentrate is the better supplement option.

If the objective is to sustain or possibly reduce forage intake, the supplement should maintain the current ratio or shift the ratio higher. This supplement should have a relatively high DOM:CP ratio. If corn is selected, the DOM:CP ratio of the total diet is virtually unchanged, and ruminal nutrient balance will not be improved.

In contrast, the wheat forage in Table 2 has a relatively low DOM:CP ratio, indicating that available protein in the rumen may be exceeding the energy supply. Therefore, a small amount of feed with a high

Table 1. An example of the impact of protein supplementation on the energy status of a 1,000-pound cow.

	Unsupplemented	Supplemented	% change
Forage crude protein, %	5	5	
Forage TDN, %	45	45	
Supplement crude protein, %	–	42	
Supplement TDN, %	–	76	
Supplement intake, lbs	0	1.8	
Forage intake, lbs	16	20.8	+30
Total daily intake, lbs	16	22.6	+41
% crude protein in total diet	5	7.9	
TDN intake, lbs	7.2	10.7	+49

Table 2. Example of the use of the DOM:CP ratio in selecting a supplement.

	Dormant forage		Wheat forage	
	Cottonseed meal	Corn	Cottonseed meal	Corn
Forage crude protein, %	5	5	25	25
Forage TDN, %	45	45	75	75
Supplement crude protein, %	45	9	45	9
Supplement TDN, %	76	88	76	88
Forage DOM:CP	9	9	3	3
Supplement DOM:CP	1.7	9.8	1.7	9.8
DOM:CP target	4 - 6	4 - 6	4 - 6	4 - 6
Better supplement choice	X			X

DOM:CP ratio will shift the diet toward the optimum.

Both scenarios are supported by research and field observations with grazing cattle. In northeast Texas, steers grazing rye/ ryegrass were fed 1 to 2 pounds/ day of a corn supplement. The cattle had a supplement conversion efficiency of 1 to 3 pounds of supplement per pound of added gain. Cattle grazing warm-season perennial grasses with DOM:CP ratios greater than 6:1 generally convert a concentrated natural protein supplement with an efficiency of 1.5 to 3 pounds of supplement per pound of added gain. The conversion efficiency of low-protein energy supplements on warm season perennials ranges from 6 to more than 10 pounds of supplement per pound of added gain.

Sources of supplemental protein

Supplemental protein is available in many forms. Feedstuffs and formulated feeds containing less than 10 percent crude protein to more than 60 percent crude protein are available. To complicate things further, crude protein may be from a natural protein source, a nonprotein nitrogen source, or a mixture of the two. An additional consideration may be the ratio of ruminally degradable protein and escape or bypass protein.

Crude protein concentration

In a review from Kansas State, supplements were categorized by crude protein content to compare intake responses (Table 3). If the objective is to optimize forage intake and use, it is easy to see that the supplement should contain more than 25 percent crude protein. These are average responses so the minimal protein content should probably be in excess of 30 percent. Intake response appeared to decline with supplements containing more than 35 percent crude protein. The decline was attributed to high levels of nonprotein nitrogen and escape protein in some of the experimental supplements.

Table 3. Average forage intake response to supplements containing various concentrations of crude protein (from R.C. Cochran, personal communication).

Supplement crude protein, %	Intake response, %
less than 15	+9
15 to 25	+23
25 to 35	+60
greater than 35	+36
overall average	+33

Escape or ruminally degradable protein

Escape protein refers to protein not degraded in the rumen that escapes into the small intestine and is then degraded. Protein concentrates of plant origin, such as cottonseed meal and soybean meal, contain ruminally degradable protein and escape protein. In situations where the objective is to stimulate or sustain forage intake, ruminally degradable protein is the first priority because of the need to provide the rumen microbes with nitrogen. Feeding a protein source with high escape potential may not stimulate ruminal activity, and forage intake and performance response will be lower. Research results favor using ruminally degradable protein sources over escape protein sources for cattle consuming forages of low protein content. According to guidelines, 60 to 70 percent of the supplemental protein should be ruminally degradable protein, and the total diet should contain 0.1 to 0.12 pounds of ruminally degradable protein per pound of digestible organic matter.

If supplying ruminally degradable protein does not improve production (see situation 2), then supplemental escape protein may be useful. The most consistent responses have been observed in cattle grazing cool-season annual (rye/ ryegrass) and perennial (orchardgrass, bromegrass) forages, especially those with 12 to 20 percent crude protein that is highly degradable in the rumen. The high degradability of the forage protein results in nitrogen being absorbed from the rumen without being converted to microbial protein. This nitrogen cannot be completely used by the animal. Therefore, supplemental protein must be supplied as escape protein. In some instances with high quality forages, both forage intake and weight gain increased when cattle were fed supplemental escape protein. This is an inconsistent response, and feeding a small quantity of an energy supplement (corn) may give the same performance response. The two supplements may accomplish the same end—supplying protein directly to the small intestine or stimulating ruminal protein synthesis.

Recent research indicates that escape protein may play a role in reproduction. Supplemental escape protein may affect postpartum interval and fertility of lactating cows by altering metabolism and endocrine function.

Nonprotein nitrogen sources

Ruminal microbes can convert nonprotein nitrogen (NPN) into microbial protein. If ruminal microbes need a source of nitrogen to stimulate digestion and intake, it would seem that NPN would be useful. Unfortunately, research does not support this concept. For reasons yet to be identified, supplements containing NPN from urea and biuret are not used as efficiently as natural protein supplements. Studies have shown that the crude protein equivalent from urea and biuret is used at an efficiency of 0 to 50 percent when supplemented to cattle on low- to moderate-quality forages. Research is under way to refine recommendations for using NPN in supplements for grazing cattle. Some feed ingredients such as corn steep liquor contain significant quantities of NPN but are used quite well by grazing cattle.

Forage availability

Forage intake does not respond to protein supplementation if forage availability is limiting. The highly efficient response to protein supplements is due in large part to the higher forage intake.

Feeding "energy"

If performance is limited by energy intake, why not directly increase energy intake with an energy supplement (low protein, high energy) rather than a more expensive protein supplement (high protein, moderate to high energy)? Because of the potential impact on forage intake and ultimately the energy status of the cattle. The varied responses to energy supplements make it difficult to predict the outcome of feeding energy supplements.

Substitution

A common frustration with feeding energy sources is the substitution effect. Substitution occurs when the supplemental feed substitutes for forage by reducing forage intake. As a result, the energy intake of the animal is not increased to the desired level because forage energy intake is reduced. As a general rule, 1 pound of an energy-dense feed reduces forage intake by 0.5 to 1 pound. The substitution rate depends on forage quality, level of protein in the supplement, energy source, and feeding rate. The substitution rate increases as forage quality increases; the rate decreases as the level of protein in the supplement increases; and the rate tends to increase as supplement intake increases.

Feeding hay also results in substitution. As the amount of hay fed daily increases, forage intake from the pasture source will decrease because of fill from the hay replacing fill from the pasture.

Feeding rate and frequency

Feeding low-protein, energy-dense supplements at rates of less than 0.3 percent of body weight per day probably has little impact on forage intake and may sometimes increase intake. As the feeding rate is pushed higher, forage intake will begin to decline due to substitution and performance will not increase as rapidly as expected (Table 4). In this study, calves grazing winter annuals were fed varied levels of a corn-based supplement. Except for the second feeding level, the supplement increased weight gain to the same degree regardless of the amount fed daily. The efficiency of supplementation declined at higher feeding rates, indicating that the supplement was probably reducing forage intake by the calves. Feeding frequency (for instance, daily vs. alternate days) may also affect animal response. Feeding smaller amounts more frequently decreases the probability of negative impacts on forage intake. Feeding larger quantities less frequently increases the likelihood of negative impacts on forage utilization (as well as the potential for bloat and acidosis).

Energy source

To sustain or possibly improve the current level of forage intake but increase the total daily energy intake, a supplement with a moderate level of protein will be required to assure adequate ruminal protein supply. Limit the quantity of starchy feed ingredients (corn, milo, wheat), and use alternative digestible fiber energy sources (soybean hulls, wheat middlings, corn gluten feed) as primary energy sources. Using these feed ingredients will not totally eliminate the possibility of substitution.

The crude protein level in these supplements is a key consideration in terms of obtaining

Table 4. Corn-based supplements for stocker cattle on winter annual pasture (Rouquette, 1995).

Supplement rate, lb/day	Added gain, lb/day	Supplement efficiency, lbs supplement/lb added gain
.74	.38	1.9:1
1.43	.77	1.9:1
2.44	.45	5.4:1
4.06	.45	9:1

the desired outcome. Feeding rates should be about 0.3 to 0.5 percent of body weight.

Producers who want to reduce forage intake should feed high rates of energy supplements (especially starchy feeds). For instance, Oklahoma research (Cravey et al., 1994) demonstrated that feeding 0.7 to 1 percent of body weight per day of a corn-based supplement resulted in a 1:1 substitution rate. However, stocking rate could be increased 33 percent without sacrificing steer gains (Table 7). This same approach may be useful in situations where stocking densities are too high during the dormant period or under drought conditions.

Supplementation strategies

Strategies for Situation 1 (Table 1)

Situation 1:

Problem: Performance is lower than desired to meet production objectives

Forage availability: Adequate and not limiting forage intake

Forage quality: Crude protein is low

Forage consumption: Lower than potential forage intake because of the low crude protein concentration

Objective: Improve performance by increasing utilization of standing forage

Strategy: Feed a small amount of supplement to stimulate intake and digestion

Supplement type: High protein content (greater than 30 percent)

Preferably all natural protein but some NPN is acceptable in limited amounts with certain classes of cattle

Minimum of 50 to 60 percent ruminally degradable protein

Feeding rate: 0.1 to 0.3 percent of body weight per day

Feeding frequency: Daily, or 2 or 3 days weekly (prorate 1 week of feed into 2 or 3 feedings)

Efficiency: 1.5 to 3 pounds supplement per pound of added weight gain in growing cattle and mature cows in mid-to-late gestation on late summer forage

Results from this approach are shown in Table 5. High protein supplements were fed in relatively small amounts to increase weight gain efficiently by stocker calves. Responses appeared to be better on rangeland than on bermudagrass, probably reflecting differences in the DOM:CP ratio of the forages.

Strategies for Situation 2:

Problem: Performance is lower than desired to meet production objectives

Forage availability: May or may not be limiting forage intake

Forage quality: May or may not be limiting forage intake

Forage consumption: May or may not be limited

Total nutrient consumption: Lower than required to meet production goals

Objective: Improve performance by supplying additional nutrients without reducing the intake and utilization of standing forage

Strategy: Feed a supplement to sustain (and possibly stimulate) forage intake but increase total energy intake

Supplement type: 20 to 30 percent crude protein

Preferably all natural protein, some NPN may be acceptable in limited amounts

Minimum of 50 to 60 percent ruminally degradable protein; however, in some cases, the protein concentration as well as the percentage escape protein may be increased to increase total protein supply

Preferably use digestible fiber feeds as the primary energy substrate

Some starchy feeds at low levels are acceptable

Feeding rate: 0.3 to 0.5 percent of body weight per day

Feeding frequency: Daily or minimum 3 days weekly (prorate 1 week of feed into 3 feedings)

Efficiency: Usually 5 to 10 pounds of supplement per pound of added weight gain in growing cattle and mature cows in mid-to-late gestation

Results in Table 6 provide a good example of this strategy. Lightweight calves were grazing rangeland. Soybean meal alone provided needed protein and improved weight gains. After

Table 5. Stocker cattle response to high protein supplement (greater than 39 percent crude protein) during the summer (adapted from various reports).

Forage	State	Feeding interval	Supplement rate, lbs/day	Added gain, lb/day
Bermudagrass	Arkansas	June - Sept	1.1	0.15
	Oklahoma	Aug - Oct	1.0	0.30
	Mississippi	July - Oct	1.36	0.22
Tallgrass prairie	Oklahoma	July - Sept	1.0	0.52
Midgrass prairie	Oklahoma	June - Sept	1.0	0.52
Sandage prairie	Oklahoma	July - Sept	1.0	0.33

Table 6. Performance of beef calves fed various supplements while grazing native range in the summer (Purvis et al., 1996).

	No supplement	Soybean meal	Soybean meal and wheat midds
Daily supplement, lbs	0	1.0	2.5
Crude protein concentration, %	—	39.6	25.4
Trial 1, 366 lb calves, May 25 - Aug 17			
Daily gain, lbs	1.59	1.76	2.01
Trial 2, 262 lb calves, July 19 - Oct 10			
Daily gain, lbs	1.08	1.35	1.50

correcting the protein deficiency, performance was enhanced by adding wheat middlings to the soybean meal and feeding at a higher rate.

Strategies for Situation 3:

Problem:Performance is currently meeting production objectives, but forage availability is anticipated to limit performance in the future

Forage availability:Currently adequate and not limiting intake but will be limited in the future

Forage quality:May be high or low

Forage consumption:Currently adequate but will be limited in the future

Objective: Maintain current level of performance but extend forage supply into the future

Strategy:Feed a supplement that will depress forage intake but maintain total energy intake

Supplement type:10 to 18 percent crude protein

Grain and grain byproducts

Feeding rate:0.7 to 1.0 percent of body weight per day (possibly higher)

Feeding frequency:Daily

Efficiency: Usually in excess of 10 pounds of supplement per pound of added weight gain in growing cattle

Allows for higher stocking densities which improves efficiency per acre rather than per head

Efficiency per acre will range from 5 to 10 pounds of added gain per acre per pound of supplement fed

Feeding steers supplement at about 0.60 percent of body weight not only improved daily gains but also reduced the land area required by a steer during winter wheat grazing (Table 7). Supplement efficiency exceeded 10 pounds supplement per pound of added weight on an individual animal basis. However, the high feeding level reduced the steers' forage intake and allowed for a higher stocking rate (head/acre). When expressed per acre of grazing land, the supplement efficiency was less than 5:1.

To control costs and optimize performance, evaluate each situation and develop a set of objectives for the feeding program.

Table 7. Supplements for stocker cattle on wheat pasture (Cravey et al., 1995).

	No supplement	Corn-based	Soybean hulls and wheat midds base
Daily supplement intake, % body weight	0	0.57	0.65
Daily gain, lbs	2.10	2.33	2.40
Supplement efficiency,			
lbs supplement/lbs added gain/head	0	12.2	10.6
lbs supplement/lbs added gain/acre	0	4.55	4.71
Stocking rate, acre/head	2.0	1.5	1.5

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Factors and Feeds for Supplementing Beef Cows

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A beef cow requires energy, protein, minerals, and vitamins in its diet. What determines how much of these nutrients is required? What determines if they need to be supplemented in the diet?

Many factors affect the amounts of required nutrients. A female performs many functions—body maintenance, activity, weight gain, reproduction, and milk production—that all require nutrients. The amount of nutrients required depends on body size, environmental conditions, how far an animal travels, desired rate of gain, stage of gestation, and level of milk production.

The nutritional value and quantity of available forage determine if nutrients need to be supplemented in the diet. During most of the year, warm-season forages are likely to be deficient in some minerals, especially phosphorus and certain trace elements like copper and zinc. In most situations, supplementation should include at least year-round provision of salt and a mineral with 8 percent to 12 percent phosphorus and a similar level of calcium. Vitamin A, which usually is low in dry or weathered forages, should be injected or fed in mineral or other supplements if it is suspected to be deficient. Mineral and vitamin supplementation should be a high priority because deficiencies can be corrected for relatively little cost.

After addressing mineral and vitamin needs, protein and energy deficiencies must be considered. Forage protein and energy vary seasonally. Warm-season forage typically becomes deficient in protein in mid-summer and again in winter. Forage lacks adequate energy content primarily in winter, but energy available to the animal is restricted more often by a limited supply of forage rather than by deficiencies in plant composition.

Factors Affecting Supplementation

Many factors affect the type and amount of protein or energy supplement that a beef cow may require. There are six critical factors that affect supplementation needs.

Forage Quantity. The amount of available forage obviously affects the need for supplemental feed. If grazing or hay will be limited, take immediate action. Reduce the number of animals in order to lessen the need for supplemental feeding of the remaining cows. As forage supply declines, the opportunity for animals to selectively graze decreases, and so does diet quality. Then, supplementation may become necessary even if animal numbers are reduced.

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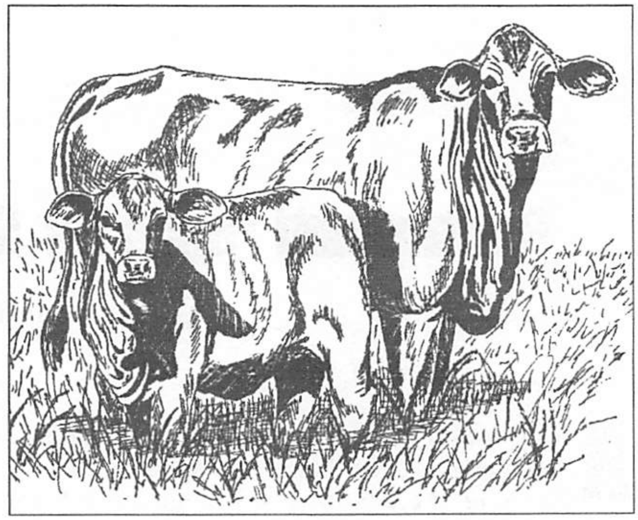
Forage Quality. Poor quality forage has less than 6 percent to 7 percent crude protein (CP) and is low in digestibility, with less than 50 percent total digestible nutrients (TDN). These deficiencies limit the amount of such forage that an animal can eat. Because both consumption and nutrient content of poor quality forage are low, supplemental needs are high. Medium quality forage (7 percent to 11 percent CP, 50 percent to 57 percent TDN) eliminates or significantly reduces the need for supplementation. High quality forage (above 12 percent to 14 percent CP and 57 percent TDN) can be consumed in the largest amounts and usually removes any need for supplementation, except possibly for high milking cows in low body condition. However, forage that is high in quality but low in quantity, a common situation in early spring, increases the need for supplementation of dietary bulk and energy. The amount a cow can eat in a day ranges from as little as 1.5 percent of body weight for very low quality forage to near 3.0 percent for very high quality forage. The typical amount is 2.0 percent to 2.5 percent.

Body Condition. The level of body condition (amount of fat) affects supplemental requirements. Low body condition markedly increases the need for supplemental nutrients, and meeting such needs often is cost prohibitive. Moderate body condition significantly reduces or eliminates the need for supplements. Fleshy cows generally need little if any supplement and the daily amount of forage required often can be reduced. If forage consumption is not reduced, higher production is possible or reserves of stored body energy can be maintained.

Body Size. The potential for forage consumption is related to body size, so larger animals may not require more supplement than smaller ones. Adjustments in stocking rate, to allow adequate amounts of forage per cow, may offset differences in size but will increase the cost per cow. But if forage is sparse or limited, larger cows require proportionately more supplement.

Milking Level. Higher milking cows can consume somewhat more forage, but not enough to completely satisfy extra needs. When forage quality is inadequate, higher milking cows need more supplement; from 50 percent to 100 percent more may be required for high versus low milk production in cows of the same body size.

Age. Young animals are still growing and require extra nutrients, but their body size is not as large as mature animals. Because of their smaller body size, growing heifers cannot consume as much forage as



mature cows. For these reasons, young females require higher quality diets than mature cows and often require more and different supplements.

Feeds for Supplementation

What are some protein and energy supplements and how should they be used?

Oilseed Meals. Cottonseed, soybean, and peanut meals often are manufactured as large pellets or cubes for feeding convenience. These are high protein (38 percent to 45 percent CP), medium to high energy sources, commonly fed at 1 pound to 3 pounds a day. Although relatively costly per ton, they often are the cheapest source of protein. These feeds are most useful when supplemental protein, and little or no energy, is needed. Oilseed meals are especially suitable for dry cows in moderate to good flesh when they have access to adequate amounts of low protein, medium energy forages.

Grain. Corn and grain sorghum (milo) are the most common low protein, high energy sources. Other grains include oats, wheat, and barley. Grains often are the cheapest sources of supplemental energy. Similar feeds include processed byproducts such as wheat mids, soybean hulls, and rice bran. These byproducts are slightly higher in protein and a little lower in energy than grains and are relatively low in starch. Starch can interfere with forage digestibility, so these are excellent supplements to forage. Feeds in this category commonly are found in breeder/range cubes.

Breeder/Range Cubes. These are most commonly 20 percent CP but also are found as 30 percent to 32 percent products. These feeds are designed to provide a combination of protein and energy, fed in larger amounts (3 to 6 pounds a day) than high protein feeds. The equivalent of a 20 percent cube can be prepared with a mix of about one-third oilseed meal and two-thirds grain. A mix of about three-fourths meal and one-fourth grain is the equivalent of a 32 percent cube. Some cubes use nonprotein nitrogen (NPN), usually urea, to supply nitrogen for potential synthesis of rumen microbial protein. Cubes with low crude fiber (below 10 percent) generally are highest in energy. Whole cottonseed, brewers grains, and some corn gluten meals are similar in protein and energy content to these cubes.

Protein Blocks and Liquids. These feeds usually contain 30 percent to 40 percent CP and typically are low to medium in energy. Their formulation or physical structure limits consumption to around 1 pound to 3 pounds daily. The protein portion often consists of 50 percent to 90 percent from NPN, but can be considerably lower. Their primary use is to provide supplemental protein on low protein, medium energy forages (below 7 percent CP, 50 percent to 52 percent TDN) where convenience of self-feeding is a priority. These feeds generally will not fill large voids of nutrient deficiency, nor support higher levels of animal performance.

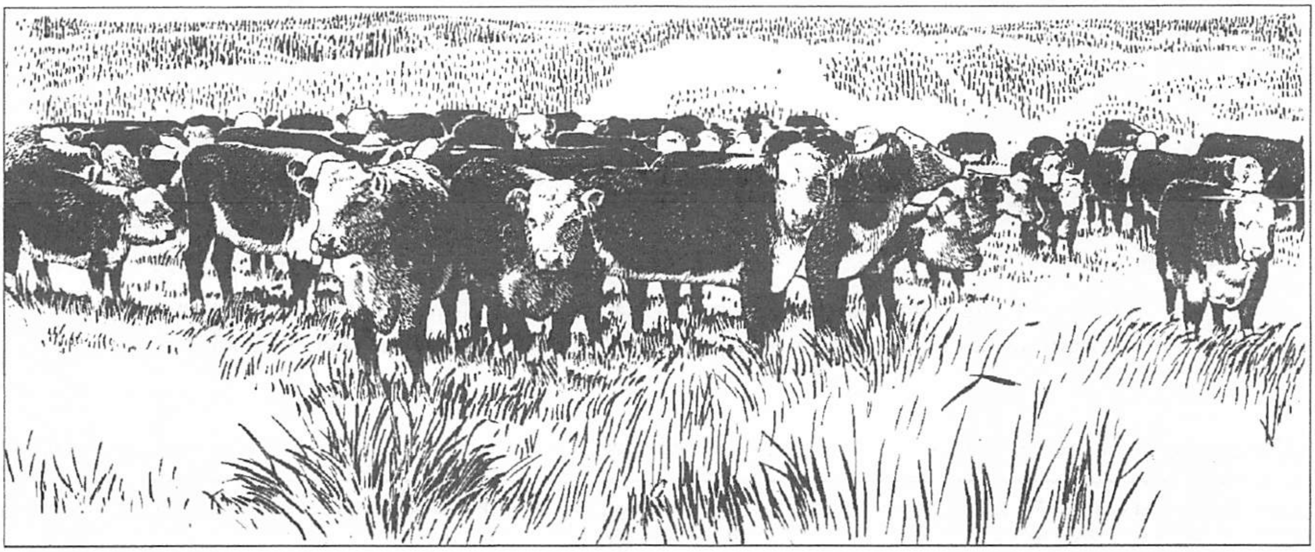
Syrup Blocks and Tubs. These generally range from 12 percent to 24 percent CP (often about half from NPN) and are medium in energy. Consumption of these blocks usually is very low (typically 1/2 pound to 1 1/2 pounds a day), so higher protein versions probably are most useful. These products are not intended to directly supply much supplemental protein or energy. Rather, their theoretical function is to stimulate rumen microbes to digest more forage and produce microbial protein, which can be utilized in the small intestine. For this to occur, sufficient amounts of at least moderately digestible forage must be available. These feeds work best when supplied year-round, allowing accumulation of body fat reserves that animals can utilize during typical fall and winter decline in forage quality and quantity. They generally will not support high performance.

Hays. High quality hays, such as alfalfa, peanut, and soybean, can be used as supplements. These medium protein (usually 15 percent to 20 percent CP), medium energy sources can be limit-fed in place of one of the feeds discussed previously. Such hays also can be fed free choice, although protein is wasted, if their cost is competitive.

Supplementation Strategies

Supplements must be chosen to meet particular nutrient deficiencies. Body condition is a key factor in the choice of supplements. Thin cows are relatively more deficient in dietary energy than in protein. In contrast, fleshier cows may need extra protein, if they need anything.

To minimize supplementation, use forage supplies logically. In general, hay (excluding supplemental alfalfa, etc.) should not be limit-fed with standing forage. Limit-feeding of hay encourages cows to reduce grazing and fails to use pastures while quality is reasonably good. For example, assume available forage for grazing or feeding includes some tame pasture (such as coastal bermudagrass), some native range, and some hay. As winter approaches, the tame pasture should be used first, native range next, and hay last. That way each forage is utilized most efficiently, and there is a better chance some hay will be left in late winter to early spring when high quality green growth begins but is limited in amount.



It is difficult to make general recommendations about supplementation of protein and energy. Usually, dry mature cows in medium or higher body condition on typical dormant warm-season pasture or low quality hay often need only 1 pound to 2 pounds a day of a high protein feed. (On extremely low quality forage, such as tall-grass prairie in winter, 3 pounds to 4 pounds of high protein feed may be needed.) A thin, dry, mature cow may require 2 pounds to 4 pounds daily, but of a medium-protein, high-energy supplement. After calving, all of these amounts essentially should be doubled.

Daily feeding usually is not necessary when using high-protein supplements such as cottonseed meal cubes. Instead, depending on the amounts, weekly required totals can be divided and fed every other day, twice a week, or even once a week. In fact, nondaily feeding of these supplements often is more efficient. However, combination protein-energy supplements, especially breeder/range cubes and meal-grain mixes, that are required in larger daily amounts, generally should be fed daily for best forage utilization, highest animal performance, and greatest efficiency.

Self-fed, controlled consumption can be accomplished with some feeds, especially oilseed meals and meal-grain mixes, by including an intake limiter such as salt. Cattle then will consume salt in maximum amounts of approximately 0.1 percent of body weight, or about 1 pound of salt consumption daily by a 1,000-pound cow. So, to obtain supplement consumption of 3 pounds daily in a 1,000-pound cow, a mix of 1 pound salt to 3 pounds supplement should be provided. When using salt to limit consumption, plenty of high quality water must be available. Also, cows consume more of a salt-limited supplement when it is located close to a water supply.

Perhaps the most common supplement is a high quality 20 percent CP breeder/range cube (high or all-natural protein and low crude fiber), or the equivalent. Such a supplement often is a compromise for the common situation of low quality forage and low to medium body condition. But this must be fed in adequate amounts, typically 3 to 6 pounds a day, to be effective. In fact, with the exception of managing weight loss in fleshy cows, there are few situations where feeding smaller amounts of such cubes is applicable. If a producer is unwilling or unable to assume the cost of required amounts of these cubes (or the equivalent), then a lower amount of a higher protein feed should be fed. But realize, however, that body condition, reproduction, productivity, and profit are likely to decline if nutrient requirements are not met.

The following Texas Agricultural Extension Service publications can provide additional information.

B-1526, "Body Condition, Nutrition and Reproduction of Beef Cows"

B-1553, "Nutrient Composition of Feeds"

B-1554, "Nutrient Requirements of Beef Cattle"

B-6056, "Mineral Supplementation of Beef Cows in Texas"

B-6067, "Supplementation Strategies for Beef Cattle"

L-2163, "Feed Label Information"

L-5194, "How to Control Cow Herd Feeding Expense"

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Texas AgriLife Extension publications can be found on the Web at: http://AgriLifebookstore.org

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Revision

B-1575

Texas Agricultural Extension Service

People Helping People

BEEF CATTLE NUTRITION

The Cow's Digestive System

Whitney Rounds and Dennis B. Herd*

Digestion in cattle is similar to digestion in man and certain other animals, except that, in cattle, foods are first subjected to microbial fermentation in the reticulo-rumen. Cattle can utilize roughages and other fiberous feedstuffs only through the action of microorganisms which are normally ingested on feed or obtained from other animals. Microorganisms in the rumen have the unique ability to break down fiberous feedstuffs to obtain the simple nutrients required for their growth. In this process, various microbial by-products of no value to the microbe, such as volatile fatty acids and B vitamins, are produced. These by-products are absorbed into the blood and are used as sources of nutrients by the animal. The microorganisms also pass from the rumen to the lower digestive tract, where they are digested and their constituent protein, vitamins and other nutrients are absorbed and utilized by the animal. The relationship of the microbes with the host cow is mutually beneficial.

DIGESTIVE TRACT ANATOMY

Man, dogs, poultry and swine have simple or monogastric stomachs (see Figure 1). The monogastric stomach is a pouch-like structure containing glands which secrete hydrochloric acid and digestive enzymes. Monogastric animals do not produce enzymes capable of breaking down cellulose, the main source of energy in forages. Forage consuming species, such as cattle and sheep, have intestinal differences which enable them to digest large amounts of fiberous material. In cattle and sheep, rumen microbes supply the digestive enzymes necessary for the breakdown of plant cellulose and hemicellulose. The cow has the stomach volume and properties necessary to assist with the microbial digestion. The ruminant digestive tract and the ruminant stomach are shown in Figure 1.

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The ruminant stomach is divided into four compartments: the rumen; reticulum; omasum; and abomasum. Digesta can flow freely between the first two compartments, the rumen and reticulum. The reticulo-rumen contains more than 50 percent of the total digestive tract capacity and most of the microbial activity takes place here. After sufficient time in the reticulo-rumen, digesta flows into the omasum. The omasum has many folds of tissue, similar to a partially open book, and contains from 6 to 8 percent of the total digestive tract capacity. The omasum is thought to aid in the reabsorption of water from digesta flowing through it, and to assist in reducing particle size. Upon leaving the omasum, digesta passes into the abomasum, which is frequently referred to as the true stomach. Like the stomach of monogastric animals, the abomasum secretes digestive enzymes which prepare digesta for absorption in the small intestines. Approximately 6 to 8 percent of the total digestive tract is taken up by the abomasum.

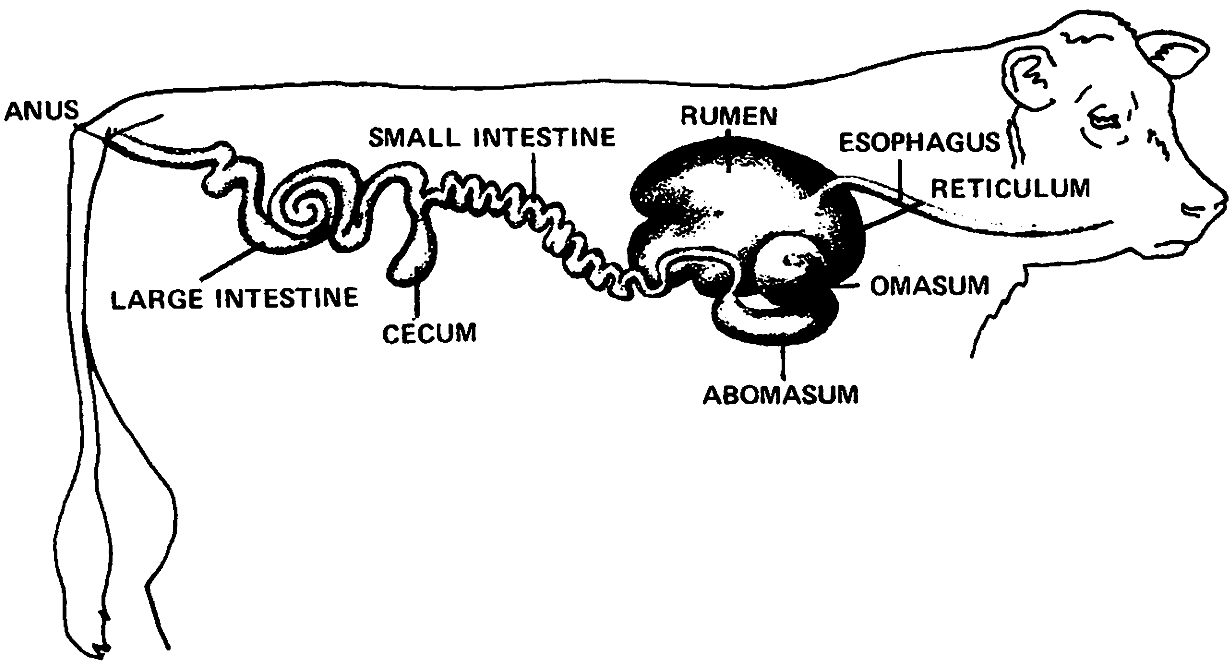
Feeds broken down to their component parts during passage through the ruminant stomach are largely absorbed in the small intestines. Absorption of protein, vitamins, simple carbohydrates, fats and amino acids takes place here. Undigestable material which will not be absorbed passes into the large intestines, where excess moisture is reabsorbed and form is given to what will become the fecal droppings.

RUMEN FERMENTATION

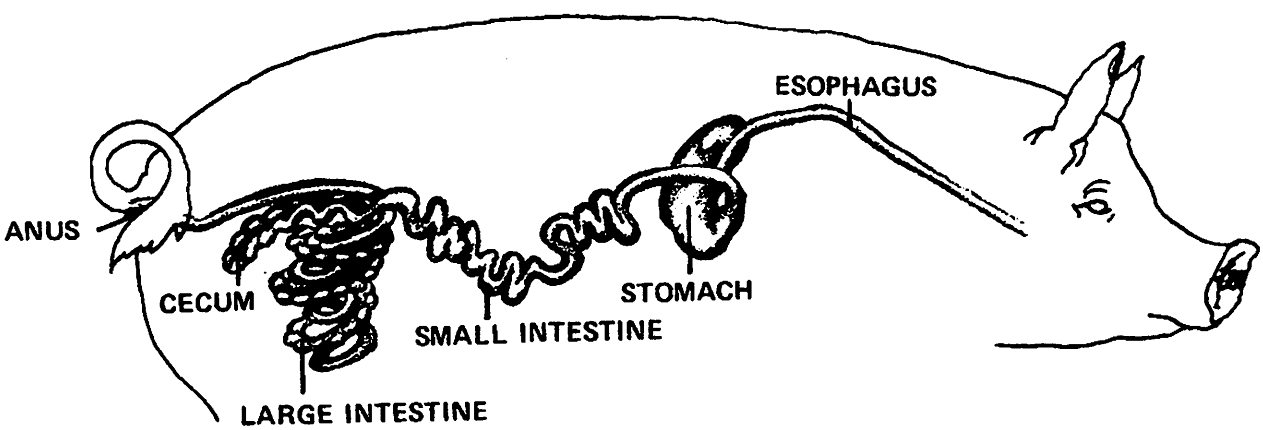
Fermentation in the rumen is made possible by a very stable environment for microbial growth. The normal pH ranges from 5.5 to 7.0; temperature ranges from 37 to 40 degrees centigrade. And food is continuously available in the rumen of properly fed animals. End products of fermentation are continuously removed, either by eructation, by absorption across the rumen wall or by passage out of the rumen to the lower digestive tract. Feed does not just "sit" in the rumen. There is continuous mixing of rumen contents

FIGURE 1.

RUMINANT DIGESTIVE TRACT



MONOGASTRIC DIGESTIVE TRACT



as digestive tract muscles contract. The mixing action helps expose food to microbial action and pass digesta through the system.

Rumen Microbes. Rumen bacteria have been classified according to the type of food they utilize or the end products they produce. Included are bacteria which digest cellulose, hemicellulose, starch, sugar, organic acids, protein and fat, as well as bacteria which produce ammonia or methane or synthesize vitamins.

Protozoa found in the rumen are larger than bacteria, and are classified according to cell morphology. Protozoa species are known to vary with the type of diet, time of year and geological location. Protozoa have been known to consume rumen bacteria. Bacteria and protozoa have food value to the cow. Dried microbes contain from 40 to 50 percent crude protein which is over 75 percent digestible.

Microbial Metabolism. Microbes in the cow's digestive tract use a portion of the nitrogen and energy from the feed for their own growth and reproduction. As they grow, microbes manufacture microbial protein and store energy in their cells. Microbes themselves become an important source of food (particularly protein) for the cow. During fermentation the microbial population converts a large portion of the feed carbohydrates (sugars, starches, cellulose and hemicelluloses) to volatile fatty acids which are the cow's main source of energy (Figure 3).

The composition of the volatile fatty acids produced in the rumen varies according to the different rations fed. Normally, acetic acid would make up 60 percent, propionic 22 percent and butyric 16 percent of the total acid production. In general, high roughage rations will contain a higher percentage of acetic acid whereas high concentrate rations will result in slightly higher levels of propionic acid. Ideally, decreasing acetic and butyric acids and increasing propionic would lead to more efficient beef production. However, high acetate levels are desired for milk fat production. High grain to roughage ratios, some feed processing techniques and certain feed additives promote propionate production at the expense of acetate.

FOOD PASSAGE THROUGH THE DIGESTIVE TRACT

The time required for food passage through the digestive tract ranges from 1 to 3 days depending upon characteristics of the food and the specific nutrient involved.

In the mouth, chewing breaks the food into smaller particles. Digestive enzymes in saliva are mixed with food before it passes down the esophagus into the reticulo-rumen (Figure 1). Although most of the feed undergoes fermentation, small amounts may pass unchanged through the rumen into the omasum and abomasum. Some of the larger food particles will be regurgitated, chewed again and reswallowed. This "chewing of the cud" is important because cattle do not initially chew their food to the extent that monogastrics do.

Protein. Protein in the diet is subjected to degradation (partial or extensive) by ruminal microorganisms (Figure 2). Microbes degrade plant proteins to various degrees and use the resulting ammonia in the synthesis of microbial protein. The extent of protein degradation varies with the type and solubility of the protein. This degradation and resynthesis process has advantages and disadvantages. Some high quality proteins may be degraded, thus reducing the quantity of essential amino acids available to the animal. (Heat and acid treatment to reduce protein solubility are currently being studied as methods of preventing degradation, thus saving the amino acids for use by the animal.) On the other hand, extremely low quality plant proteins may be upgraded during digestion to a higher quality microbial protein. Plant proteins not degraded in the rumen along with microbial protein are passed to the lower tract. Digestive enzymes secreted in the abomasum break both plant and microbial protein into their component amino acids which are absorbed from the small intestines.

Non-protein nitrogen can be used as a substitute for plant nitrogen. Rumen microbes can use the non-protein nitrogen in the synthesis of microbial protein.

Carbohydrates. Carbohydrates in the diet also are degraded by rumen microorganisms (Figure 3). Volatile fatty acids and gases (methane and carbon dioxide) are the end products of this process. Volatile fatty acids produced by rumen microbes are absorbed directly from the rumen. Gases are eliminated through eructation.

Fiber, a complex carbohydrate, is composed of lignin, cellulose and hemicellulose. Lignin is very resistant to microbial attack, therefore little of it is digested. Cellulose is more readily digested than lignin, and hemicellulose is the most digestible of the three. Starches and sugars also are readily converted to acids and gases. Unfermented feed residues and microbial cells are left to pass through the omasum to the abomasum. In the abomasum, the secretion of digestive enzymes prepares the foodstuffs for absorption in the small intestine.

Fats. Some hydrogenation (addition of hydrogen) of unsaturated acids takes place in the rumen (Figure 4). Unsaturated dietary fat (soft fat) subjected to microbial action in the rumen is transformed to a hard or a saturated fat. Most fats are passed to the abomasum and small intestine where absorption occurs.

FIGURE 2. DIGESTION AND UTILIZATION OF PROTEIN BY CATTLE

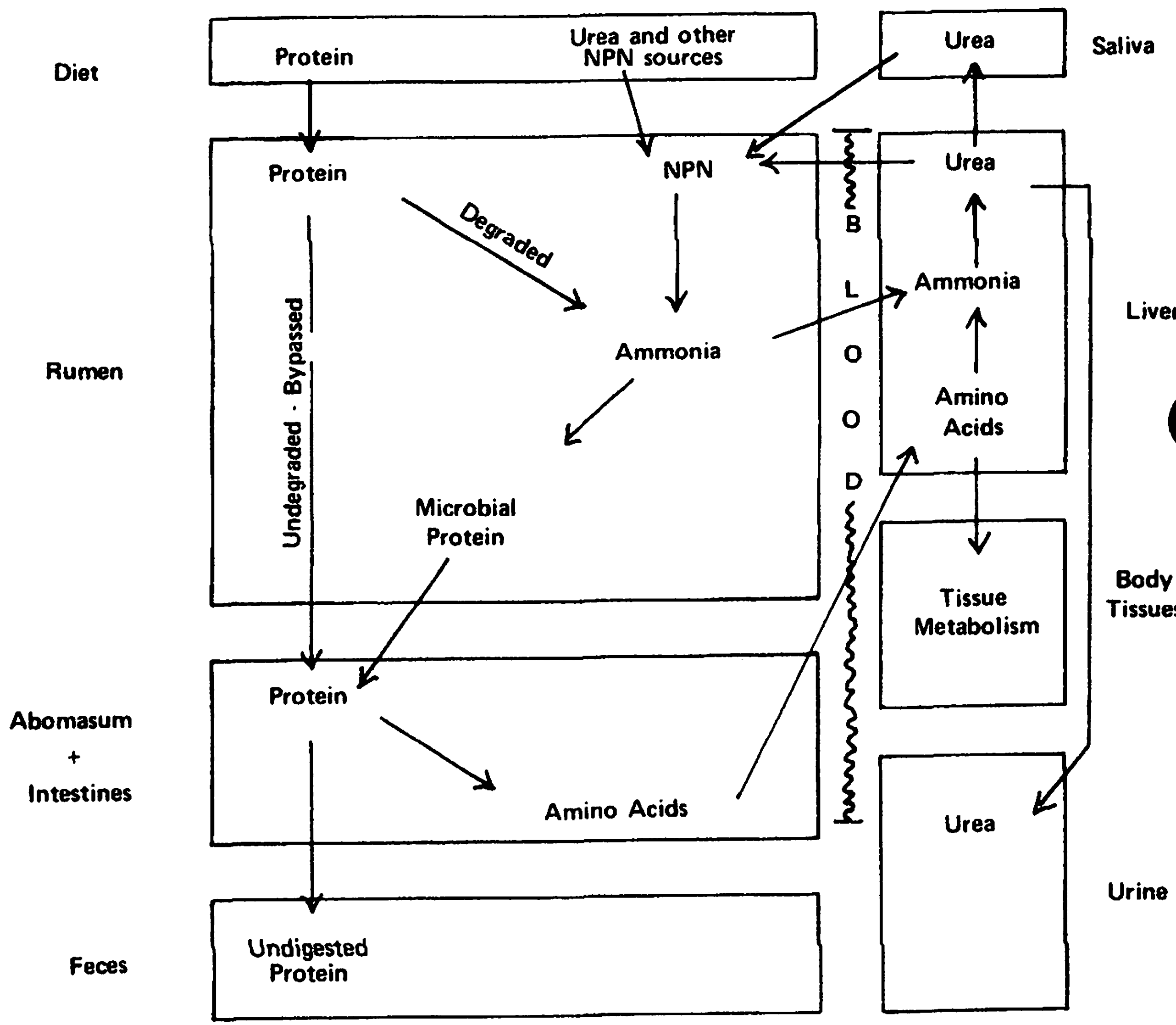


FIGURE 3. DIGESTION AND UTILIZATION OF CARBOHYDRATES

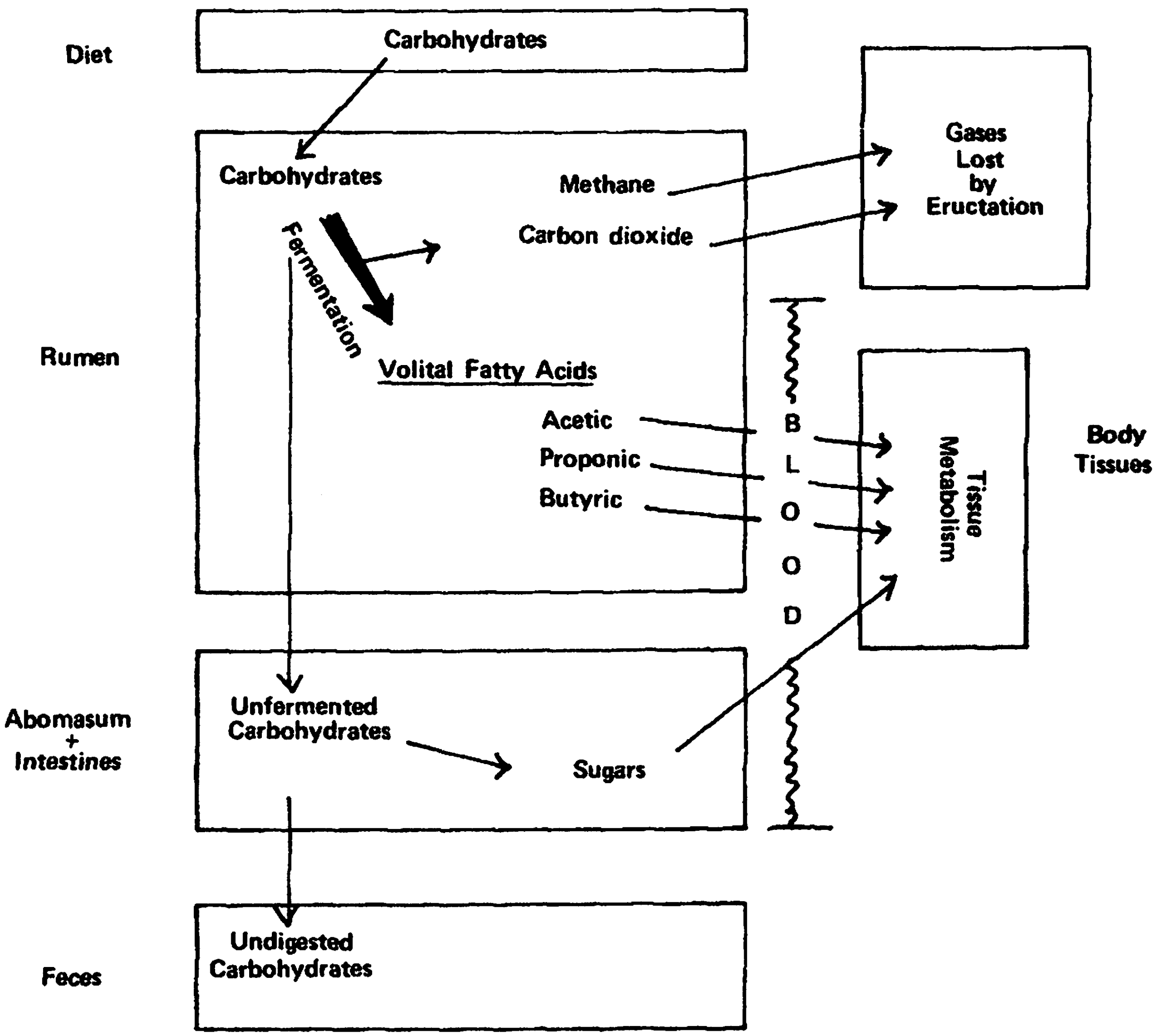
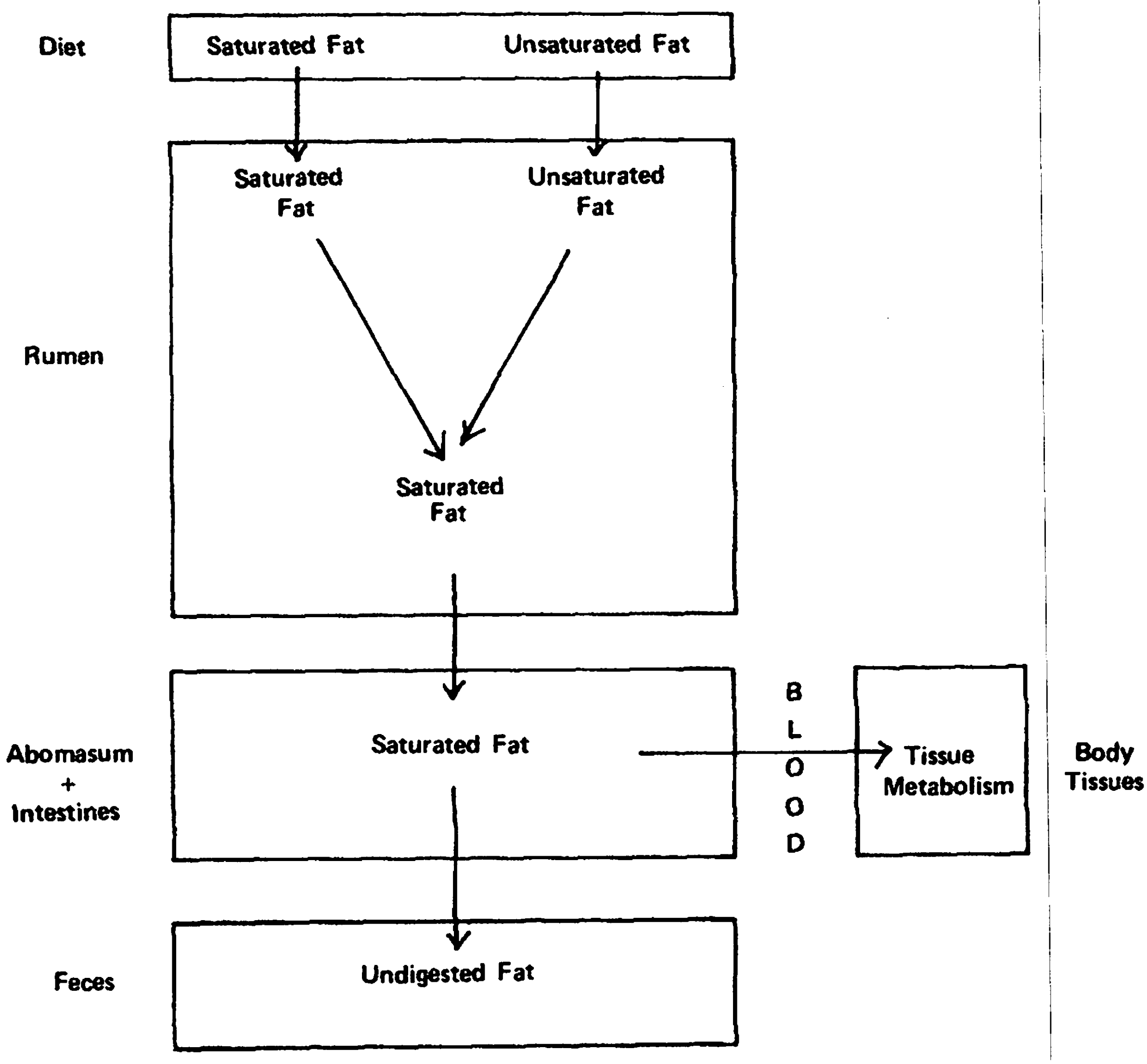


FIGURE 4. DIGESTION AND UTILIZATION OF FAT BY CATTLE



ADVANTAGES OF RUMEN FERMENTATION

Fermentation by the rumen microorganisms gives the ruminant animal several unique capabilities:

1. Forage Utilization

   Forage and roughage account for a large quantity of the total world feed resources. Rumen microorganisms, through the production of enzymes, allow the ruminant animal to use the fiberous portion of these roughages as an energy source.

2. Non-Protein Nitrogen Utilization

   Rumen microorganisms can manufacture protein from non-protein nitrogen. This microbial protein is later digested and supplies the animal with needed amino acids. Nonruminants must obtain essential amino acids directly from their diets.

3. Vitamin Synthesis

   Rumen microorganisms can synthesize the B-complex vitamins and vitamin K. Dietary supplementation is not required, except in sick animals where rumen function is impaired.

DISADVANTAGES OF RUMEN FERMENTATION

Fermentation in the rumen and reticulum may cause inefficient conversions of dietary constituents:

1. Waste Gas Production

   Carbon dioxide and methane are by-products of the breakdown of carbohydrates, and are eliminated from the rumen. Sugars and starches would be of more benefit if they could be passed to the lower digestive tract for absorption as sugar.

2. Wasted Protein and Nitrogen

   Ammonia and organic acids are the end result of protein breakdown. Some of the resulting ammonia is recombined to form microbial protein. However, under some conditions ammonia is lost, absorbed across the rumen wall and excreted in the urine. The loss of ammonia in the digestive process is inefficient.

3. Heat of Fermentation

   Rumen microbes breaking down feedstuffs and reforming them generate heat. This heat of fermentation is a disadvantage in most instances. In cold environments, however, this heat will help meet the animal's maintenance energy requirement.

4. Digestive Disturbances

   Bloat and acidosis are cases of rumen malfunction. Bloat results when fermentation gases are produced faster than they can be disposed of. Acidosis is the result of an excessive breakdown of readily available carbohydrates. In feedlot cattle, acidosis usually leads to an erosion of the rumen wall and liver abscesses.

The ruminant animal is unique because of the mutually beneficial symbiotic relationship that exists with the microbes living in its digestive tract. Through the action of these microbes, high-fiber feed sources become assets. Non-protein nitrogen compounds can be used by the ruminant in the production of microbial protein. Animals with simple stomachs cannot use cellulose or non-protein nitrogen.

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Marketing Cull Cows: Understanding What Determines Value

by Ron Gill, Ph.D., Extension Livestock Specialist, Texas A&M University

Under drought conditions it is likely many operations will experience lower conception rates than normal. Feed costs and uncertainty about growing seasons next year make culling of these open cows appear to be the correct management decision. In an average year, cull cows will represent 10-20% of gross revenue on a cow-calf operation.

Informed marketing, rather than simply selling, can add to income from cull cow and bull sales. When factors affecting value are understood, culls can be marketed to take advantage of seasonal trends and fluctuations in cow condition. Factors affecting value are sale weight, body condition, ,muscling, quality and blemishes, all of which can be managed at the ranch to add value to the culls. Cull cow value is based on percent lean meat yield and live weight.

Cows are graded into four broad categories, Canner, Cutter, Utility, and Commercial. Table 1 indicates characteristics associated with each grade. Canners are thin, emaciated cows which have lost muscle mass due to poor nutrition or health. Cutters are thin to moderate in flesh. Little muscle mass has been lost but no excess condition is being carried. Cows grading Utility carry higher levels of condition. (It is a fat cow grade.) Utility is further divided into Boning and Breaking classifications as well. Cow tenders, strips and top rounds can be, and often are, pulled from cows grading Boning Utility.

Breaking Utility cows have sufficient intramuscular fat (marbling) and muscling for the primals (particularly cuts from the rib and loin) to be used outside the ground meat trade. This greatly increases the carcass value of these cows. Cows that will grade Breaking Utility are very difficult, if not impossible, to determine before processing. It is not practical to manage cows with the goal of producing Breaking Utility grade.

Carcasses grading Commercial are normally from younger cows that fall into C maturity (approximately 42 months old or older). Primal cuts are routinely pulled from these cattle and use in restaurant trade.

Canner cows bring a lower price per pound than Cutter, Utility or Commercial cows. Cutters normally have a higher price per pound than Canner or Utility. Recently, Utility cows are selling for more per pound than Cutter cows. Utility cows bring a price per pound that is usually intermediate to Cutters and Canners, but will often have more total dollar income due to extra live. Producers should target cows for the high yielding Cutter or Boning Utility grade.

Table 1. Cull Cow Grades and Characteristics

Grade	Dressing Percentage	Lean Content of Trimmings	Cow BCS	Current[a] Mkt Value $/cwt
Canner	40 to 46	90 to 92	1 to 3	18 to 25[b]
Cutter	45 to 49	88 to 90	4 to 5	20 to 34
Utility				
Boning	50 to 52	78 to 83	5 to 9	25 to 34
Breaking	52 to 54	76 to 82	6 to 9	38 to 50
Commercial	55 to 60	70 to 80	5 to 9	38 to 50

[a] Values reported as of July 24, 1998

[b] Cows could be subject to light carcass discounts.

Caution should be exercised when marketing cows directly to a packing plant. Cows that grade high Cutter and Utility will probably be discounted if they have too much external fat. Packers discount what they classify as fat cows. Unlike processing facilities for feedlot cattle, cow processors sort cow carcasses according to the described criteria. They are not graded by a USDA grader or stamped with the packer grades.

When selling cows directly to the packer another discount to be aware of is for light carcasses. Carcasses weighing less than 350 pounds receive up to $15/cwt discount. The Canner grade is most likely to produce light carcasses. Thin, emaciated cows are discounted at the sale barn to compensate for the probability of light carcasses. For example, a cow with a body condition score (BCS) of 3, weighing 800 pounds and dressing 40%, would hang up a 320 pound carcass. A $15/cwt discount equals $48 per head, or $6/cwt on a live-weight basis. This is in addition to the lower price per pound for Canner cows.

Cows are inspected by USDA inspectors at processing. Condemnations are the result of the USDA inspector, not plant management. Condemnation is due to pathological conditions only, most commonly due to cancerous conditions which have spread out of a localized organ such as an eye.

The most competitive environment for selling cull cows is still the local auction facility. Unless a prearranged price is agreed upon and conditions for determining carcass value are set, it is risky to sell directly to a processing plant.

To maximize value of cull cows, consider some or all of the following changes in management if they appear to be profitable.

1. Add weight to thin cull cows before selling. This is particularly valuable when cows are BCS 3 or lower at culling. High quality forage efficiently replenishes muscle mass on cows. Extremely old cows may not gain as efficient as younger cows. Target a BCS of 5 for light muscled cows and BCS 5-6 for heavier muscled cows.

2. Cull old cows before they lose their teeth, decline in body condition and fail to breed. Besides having lower cull weight and value, such cows have also weaned lighter calves than the younger cows for probably at least two years.

3. Explore selling directly to a packer on a prearranged price. Caution should be exercised! Bids are more competitive at local auctions. Only a knowledgeable producer should attempt to market good quality cows directly to a packer.

4. Market crippled cattle directly to a packer, without going through usual marketing channels. Cows with other blemishes, such as bad eyes, probably should also be sold directly to a packer.

5. Sell cows before they become fat (BCS 8-9). Fat cows are discounted for low lean yield regardless of their potential to classify as Breaking Utility.

6. Sell cows outside seasonal marketing trends. Cull cow prices are normally lowest in October and November. If possible, consider marketing between February and September when slaughter rates are lower.

7. Consider cull cows as a valuable asset and handle them as such. Bruising is a major problem with cull cows. Most bruises are caused by rough handling and hauling from the time they are sorted at the ranch until they are processed at the cow plant.

8. Be cautious and concerned about withdrawal times when marketing cows which have been treated with animal health products.

Summary

Sell early before all that is left is a shell of a cow. Try not to market cows that are too thin or too fat. Sell before blemishes become problems. Sell crippled cattle and cows with obvious blemishes directly to the packer. Eliminate small framed cows, which produce less pounds of saleable product of less value to the ground meat processor, a double loser. Reasonable cow weights should be 1000-1250 pounds. Moderate framed cows (frame score 5) with average muscling in a BCS 5 should weight from 1150-1250 pounds at maturity.

Obviously light muscled, early maturing bulls should not be purchased in the first place. However, cull bulls should be marketed with as much muscling as possible and as little fat as practical.

Produced by the TAMU Department of Animal Science, The Texas A&M University System
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Bovine Trichomoniasis

Tom Hairgrove and Ron Gill*

Bovine trichomoniasis (Trich) is a **venereal disease** of cattle caused by the protozoan *Tritrichomonas foetus.* This disease causes early pregnancy loss and occasional late-term abortions; it may also extend the breeding/calving season.

Although losses are observed in the cow, *T. foetus* lives on the surface of the penis and prepuce of the bull and in the reproductive tract of the cow. Trich prefers a reduced oxygen environment, and it multiplies in the small folds of tissue (crypts) on the bull's penis. Because older bulls have more numerous and deeper crypts and are more easily infected, using young bulls is part of a disease management strategy. There are no obvious signs of Trich in the male, and pregnancy loss is the only sign of the disease in the female.

Transmission of the disease occurs during natural breeding. A bull can infect a cow and a cow can infect a bull. However, most infected cows eventually clear the infection. Once a bull is infected, it remains so for life. Therefore, most control programs focus primarily on the detection and elimination of infected bulls.

During breeding, organisms from the surface of the penis are left in the vagina where they multiply and invade the uterus to create an infection. Cows can still conceive during the few weeks it takes for the uterine infection to develop. Once the organism causes sufficient damage to the lining of the reproductive tract, the cow miscarries or aborts. Cows will naturally clear the infection within a few weeks to a few months and experience a brief period of immunity to the disease. After clearing the infection, cows can rebreed and carry a fetus to term. The period of immunity, though, is short and will not protect subsequent pregnancies if the cow is re-exposed to an infected bull.

Cows exposed to Trich cannot be considered safe in calf until they are at least 120 days pregnant; open cows cannot be considered free of infection until they have had at least 90 days of sexual rest and are examined and cleared by a veterinarian. Only then should they be placed back into the breeding herd. All newly acquired cows that are less than 120 days pregnant should be isolated from the breeding herd. They may be placed in the breeding herd once they are four months pregnant.

Because approximately 2 percent of infected cows will have a swollen uterus that contains pus (pyometra) and remain infective, all open cows should be examined by a veterinarian. Cows with pyometra should be sent to slaughter. There is no

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treatment for infected bulls; send them to slaughter.

Trich should be suspected in herds with poor conception rates and extended calving seasons. Infected herds can produce conception rates that range from slightly subnormal to 50 percent or lower, depending on the length of time the disease is in the herd and the number of animals that are infected. Conception rates in herds with controlled breeding seasons of 90 days or less will be even poorer. Shorter breeding seasons expose the problem more dramatically and can actually reduce the long-term production and economic losses caused by herd infection.

Because Trich develops gradually and is not readily apparent, it is better to prevent exposing the herd to the disease rather than trying to control or eradicate it. Trich enters a herd or ranch *only* via infected bulls, cows or heifers. Again, transmission is from infected bulls to cows or from infected cows to bulls. To eliminate Trich from a herd, allow infected cows to clear the infection and eliminate infected bulls altogether.

A vaccine is available for healthy cattle to aid in the prevention of disease caused by *T. foetus*. Use of this vaccine in herds with high risk of exposure has been shown to help reduce the economic impact of Trich when administered properly and in exact accordance to the label. It has also been shown to help infected cows recover more rapidly. This vaccine does not prevent all abortions; however using it in addition to other best management practices will minimize reproductive losses.

Economic losses caused by bovine trichomoniasis can be avoided or minimized by practicing sound biosecurity principles:

1. Maintain good perimeter fences to segregate cattle of unknown status. Fences are the first line of defense in preventing the introduction of Trich in the herd.
2. Keep the bull battery as young as possible. Buy only virgin bulls and heifers, preferably from the original breeder. Unless the virginity of bulls can be positively confirmed, test all bulls before adding them to the herd. All bulls of unknown status should have three negative tests using PCR or culture. These tests should be administered at least one week apart, and bulls should have no contact with cows within one week of the initial test.
3. Implement a defined breeding season. Trich can go undetected in continuous-breeding herds.
4. Identify herd sires and record the breeding group of each bull. If the herd becomes infected, this will make it easier to isolate the problem and start management protocols to eliminate the disease.
5. Consider keeping bulls in the same breeding groups for several breeding seasons. Should there be a false negative bull in the battery, this will keep uninfected cattle from being exposed.
6. Consider small sire groups (but not necessarily single-sire), versus large sire herds, to avoid infecting many bulls in a single season. Monitor pregnancy closely in one-herd grazing systems and implement an annual bull testing program to detect introduction of Trich during the first breeding season.
7. Consider artificial insemination to avoid introducing Trich or to help break the cycle of infection in a herd. Reputable semen companies repeatedly test bulls for many diseases including Trich, to ensure the semen is not contaminated.
8. Avoid buying open or short-bred (less than 120 days) cows. Open or short bred cows from unknown sources are particularly risky and must be quarantined and examined before they are added to the herd.
9. If you buy replacement cows, isolate them from the existing herd during the first breeding season.
10. If biosecurity measures cannot be adequately implemented or other risk factors exist for the introduction of Trich into the herd vaccinating the cow herd can be utilized to help mitigate economic losses.

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ESTABLISHING HERD IMMUNITY

Ronald Gill[1]

Developing herd immunity is becoming more important as the incidence and spread of disease continues to increase. Increased movement of cattle throughout our industry increases the odds of exposure to pathogens that were not common in the cow calf industry several years ago. Because the increased number of diseases, higher levels of exposure and the incidence of "outbreaks" it makes good management sense to immunize your herd as adequately as possible.

In order to establish **"herd"** immunity every ranch needs an individual plan. There is no "one" program that fits everyone. However, there are several things that are common to most cattle operations. Herd immunity begins with proper immunization and management of replacement females entering the herd. It doesn't matter whether cows are purchased or raised and retained into the breeding herd, the time to immunize replacement females is prior to placement into the breeding herd.

Replacement heifers that are retained into the herd should be immunized against as many potential pathogens as possible between weaning and breeding. This is normally a six-month window in which valuable management practices can be implemented. Unfortunately most of the time little to nothing is down to immunize these heifers. Lifelong immunity can be established during this weaning phase with virtually no risk to the rest of the cow herd.

Purchased cows should always be quarantined from the rest of the herd. Quarantine should last for at least three weeks. This also allows time to established immunity in these cows before they expose the rest of the herd to pathogens or before the rest of the herd exposes them to potentially harmful organisms.

Regardless of the diseases targeted in the immunization program all cattle have to be administered two vaccinations for each disease. An initial vaccination and a booster vaccination **have** to be given to each and every individual to establish initial immunity. Not only do they have to given, vaccines they have to be handled and administered properly. Additional information on administration and handling of vaccine can be received by contacting the extension office for a copy of ***Chute-Side Cattle Working***.

It is difficult to make blanket statements about what a herd needs to be immunized against. However, there are several diseases that are prevalent enough and costly enough to the industry that all producers should include them in a vaccination and immunization program. Others may be ranch or area specific and can or should be included after consultation with your veterinarian.

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Targeted Pathogens

The most common disease causing a problem in Texas cow herds is Leptospirosis. There are several strains of Lepto (as it commonly referred to as), most vaccines provide protection for the five most common strains of Lepto. Lepto can be spread between cattle and wildlife so there is always a chance of exposure. It can be spread through drinking water and through animal contact. Never assume your cattle will not be exposed.

Lepto vaccines, even under the best of conditions, do not provide for more than six months of adequate immunity to vaccinated animals. Lepto vaccinations need to be boostered 30 to 60 days prior to the beginning of the transmission season. Initial immunization should be given during the development phase for heifers and the quarantine period for replacement cows and bulls.

Respiratory diseases: The pathogens involved in the Bovine Respiratory Disease (BRD) complex can also cause problems in the reproductive performance of the breeding herd. By immunizing the cow herd you can protect against reproductive losses and reduce death and sickness losses in the calf-crop resulting from viral infections. The viral component of BRD is comprised of Infectious Bovine Rhinotracheitis (IBR), Parainfluenza 3 (PI3), Bovine Viral Diarrhea (BVD) and Bovine Respiratory Syncytial Virus (BRSV).

Several strains of bacteria are also components in BRD. These bacteria are normally associated as secondary infections that occur after viral lesions are formed and immunity is impaired by one or more of the viral components. When death occurs due to respiratory disease it is usually due to complications from bacterial infections. Bacteria most commonly associated with BRD are *Pasteurella Hemolytica* (PH), *Pasteurella Multocida* (PM), and *Haemophilus Somnus* (HS). Of these bacterial pathogens PH is the most prevalent.

In calves there can be losses simply due to bacterial infections. Calf pneumonia causes a fairly quick death in infected calves. Often calves will die within 48 hours of initial symptoms if not treated with antibiotics.

There are many vaccines on the market to aid in the prevention of BRD. Research and field trials are demonstrating the effectiveness of Modified Live Vaccines (MLV) when used in development of herd immunity. Although currently limited to use in non-pregnant cows, calves nursing non-pregnant cows and weaned calves, these products establish a higher level of immunity than Killed (K) viral vaccines. These K products can be used effectively when MLV vaccines cannot be used. The most logical time to use K vaccines is in the immunization of pregnant purchased cows during the quarantine period. All other animals can be immunized more effectively with use of MLV vaccines. Retained heifers should be immunized with MLV products during the weaning and development phase. Some veterinarians are currently recommending vaccination of one to two month old calves with MLV vaccines prior to the breeding season for the cow herd. Although this is not "practical" for most operations, if BRD or it's associated pathogens are a problem it may be the best approach to controlling losses.

If PH, PM or HS are a problem by themselves there are vaccines that can aid in the prevention of these diseases as well. Of particular concern in the breeding herd is HS. This bacteria can also cause late term abortions. Control is possible with an effective vaccination program and sanitary management of the cow-herd. Since these organisms are a problem primarily in weaned calves in makes sense to include these in the vaccination program during the weaning and development phase.

Sexually transmitted diseases: The most common sexually transmitted diseases are Campylobacteriosis, (more commonly referred to as Vibriosis or Vibrio) and Trichomoniasis (Trich). Vibrio is a bacterial infection that causes pregnancy losses in early gestation. Vibrio can be controlled with a properly timed vaccination program. For the most effective control the breeding herd should be vaccinated approximately 60 days prior to the onset of the breeding season. This is not a time that we normally gather cows and work them through the chute. However, if Vibrio is a problem this will be necessary to prevent the spread of the disease. Realistically, vibrio vaccines can be given when the calves are weaned and the cows are palpated, dewormed, and other annual vaccination boosters are given.

Trich is an infection caused by a protozoa. It also causes early embryonic losses but unlike Vibrio there is normally a severe infection and metritis associated with Trich. This disease is difficult to isolate in cultures taken from cows or bulls. Vaccines have recently become available to aid in the prevention and control of the organism. The most effective way to avoid infecting the herd is to purchase bulls from known origin and quarantine all incoming cows. If you want to purchase bulls of unknown origin three cultures are normally needed before the bull can be called clean. If the cow herd is infected it is common to see conception rates in the 30 to 40% range during the first year. Conception will normally increase in the following years. It will normally take five years are longer for pregnancy rates to approach normal following herd infection with Trich. The most effective way to deal with Trich is through management not vaccination. **Do not purchase bulls of unknown origin.**

Brucellosis is another disease that has plagued our industry for years. Although the Brucellosis eradication program has been plagued with problems for a long time the efforts of the state and federal agencies are close to showing long awaited results. Texas is very close to eradicating the disease. However, we are not there yet. To aid in this fight it is still wise to vaccinate heifers against Brucellosis. This needs to be done before heifers reach 10 months of age. It is best if heifers are vaccinated between 3 and 6 months of age. From a practical standpoint it makes sense to vaccinate all potential replacement heifers against brucellosis at weaning. The older a heifer is the greater the chance of her becoming a false positive on the "card test". If a heifer is over a year old do not vaccinate her against brucellosis.

A licenced veterinarian must administer the Brucellosis vaccine. It is the only one we have discussed that has to be given by the veterinarian. However, if you have any reluctance in what to vaccinate for or what or how to administer vaccines to cattle have your veterinarian administer all of the initial vaccines at the time Brucellosis vaccine is given. However, remember that Brucellosis vaccine does not have to be boostered so all other vaccines will need to be boosted in three to four weeks.

Diseases to vaccinate every cowherd against during weaning and quarantine

Disease organism	Common name
Leptospirosis -	Lepto or L-5
Infectious Bovine Rhinotracheitis -	IBR
Parainfluenza 3 -	PI 3
Bovine Viral Diarrhea -	BVD
Bovine Respiratory Syncytial Virus -	BRSV
Campylobacteriosis -	Vibrio
Haemophilus Somnus -	H. Somnus
Clostridials -	Blackleg vaccine, (4-way, 7-way or 8-way)
Brucellosis - (During weaning only)	Bangs

Diseases to consider including in a herd vaccination program

Anaplasmosis	Anaplaz
Escherichia coli	E. coli
Salmonella	Salmonella
Pasteurella Hemolytica -	Hemolytica
Pasteurella Multocida -	Multocida
Trichomoniasis -	Trich
Anthrax - (Seldom a problem in this area)	Anthrax

With the exception of Brucellosis the cow herd should also be administered a "booster" annually. The booster should be given two to three months prior to calving to stimulate the production of higher quality colostrum for the newborn. The exception to that would be the sexually transmitted diseases which should be given 60 days prior to the breeding season.

Basic Vaccination Schedule

Calves: Birth to 3 months of age*

E. coli
P. Hemolytica
IBR/PI 3 - (intranasal)

Calves: 2-6 months of age

Clostridials (7-way Blackleg)
IBR/PI 3 - (intranasal)
Lepto
H. Somnus
P. Hemolytica*

Weaned Calves and Open Replacement Heifers:

<u>At weaning or upon arrival</u>
Clostridials (7-way Blackleg)
IBR, PI 3, BVD, BRSV (Modified Live Virus)
Lepto-5
Vibrio
H. Somnus
Brucellosis

<u>2 to 4 weeks post weaning/arrival</u>
Clostridials (7-way Blackleg)
IBR, PI 3, BVD, BRSV (Modified Live Virus)
Lepto-5
Vibrio
H. Somnus
Brucellosis **

Purchased Cows:

<u>Upon arrival</u>
Clostridials (7-way Blackleg)
IBR, PI 3, BVD, BRSV (Killed product if pregnant, MLV if open)
Lepto-5
Vibrio
H. Somnus

<u>3 to 4 weeks after arrival</u>
Clostridials (7-way Blackleg)
IBR, PI 3, BVD, BRSV (Killed product if pregnant, MLV if open)
Lepto-5
Vibrio
H. Somnus

Mature Cow Herd

60 days prior to calving (or at weaning time)
Booster:
Clostridials (7-way Blackleg)
IBR, PI 3, BVD, BRSV (Killed product if pregnant, MLV if open)
Lepto-5
Vibrio ***
H. Somnus

60 days prior to the beginning of the breeding season
Vibrio

*May not be necessary on some operations.
**Only vaccinate if not done at weaning.
***Vaccinate for vibrio only if it cannot be done 60 prior to breeding.

Special Consideration

Calf Scours - If scours are a problem consider addition of the following vaccinations.

Cow herd - 60 days precalving
E. coli
Salmonella
Rotavirus
Coronavirus

Calves at birth
E. coli (administer orally immediately after birth)

Where Diseases Have a Major Impact on the Cow Herd

Type of organism	Respiratory	Reproduction	Calf Sickness/Death
Viral	IBR	IBR (IPV)	IBR
	PI 3		PI 3
	BVD	BVD	BVD
	BRSV		?
			Rotavirus
			Coronavirus
Bacterial		Lepto	Lepto
		Vibrio	
	P. Hemolytica		P. Hemolytica
	P. Multocida		P. Multocida
	H. Somnus	H. Somnus	H. Somnus
		Brucellosis	
	E. coli		E. coli
	Salmonella		Salmonella
Protozoa		Trichomoniasis	
			Cryptosporidium

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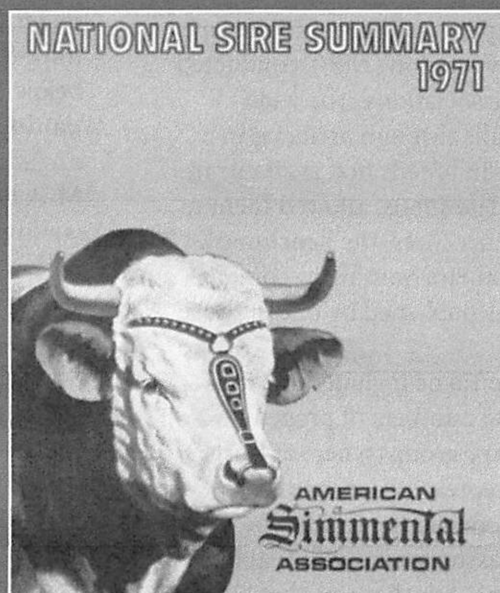
Texas Adapted Genetic Strategies VIII:
Expected Progeny Difference (EPD)



The first EPD evaluation. (Courtesy of American Simmental Association)

Stephen P. Hammack* and Joe C. Paschal*

When evaluating prospective breeding animals, it is helpful to have an estimate of their genetic transmitting potential. For most production traits, this estimate is best calculated using records of performance.

The first performance records of beef cattle were primarily weights or weight gains measured at weaning or as yearlings. Sound comparisons of individuals were often impossible because of animal and management differences. Standard adjustments were developed for calf age, sex, and age of dam, but there were no good ways to adjust for differences in management, nutrition, location, season, and year. So the comparisons had to be limited to animals managed alike in a contemporary group.

To facilitate comparisons, ratios were sometimes calculated for individual animal performance within a contemporary group; however, these ratios still contained unaccounted-for differences between groups.

Progress in genetic evaluation came with Estimated Breeding Value (EBV), which used ratios calculated within a contemporary group. EBV added an animal's own records to those of relatives and progeny. It also incorporated heritability, the average part of the difference in a trait derived from transmittable genetic content, which is not the same for all traits.

However, EBV still consisted mostly of within-group records. Because this limitation was often ignored, faulty comparisons were sometimes made of EBVs from different groups or herds.

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Texas Adapted Genetic Strategies

National Sire Evaluation

More improvement in genetic evaluation came with Expected Progeny Difference (EPD). The term *expected* can be misleading as it implies a high degree of certainty, which may or may not be true. *Predicted* or *estimated* would probably be better terms than expected.

As was true for EBV, the basis of EPD is ratios within a contemporary group, but EPD has more scope and precision. With EPD, more valid comparisons can be made of animals **across** contemporary groups, not just **within** a single group.

The first practical implementation of EPD came through National Sire Evaluation (NSE), conducted by some breed registry associations. The widespread use of popular bulls through artificial insemination, particularly in breeds first available in the United States in the late 1960s, allowed them to serve as so-called Reference Sires, the benchmark in NSE. The first National Sire Summary, comparing EPDs of 13 bulls, was published by one of those breeds in 1971.

The only bulls that could be included in NSE were those with adequate numbers of progeny managed in contemporary groups where at least one Reference Sire was represented. Some often incorrect assumptions reduced the validity of the estimates. One of these assumptions was that bulls are not genetically related. Another was that bulls are mated to females of equal genetic merit. It was assumed that no progeny are culled before all records are collected and that breed averages for traits do not change over time.

National Cattle Evaluation

Refined mathematical techniques and expanded computing capacity made possible the next step in genetic prediction, National Cattle Evaluation (NCE). This evaluation compares animals within a breed more accurately than does NSE. All major breed associations have such programs. Using NCE, breed-association EPD programs include:

- Data from the individual, relatives, and progeny
- An adjustment for differences in genetic merit of mates
- Genetic correlation between traits
- Adjustments for genetic change over time and genetic relationships among individuals
- Adjustments for differences between contemporary groups in environment and management, such as climate and nutrition
- The requirement by some associations for Total Herd Reporting, which provides records on more individuals
- No more Reference Sires, because any individual with progeny in more than one contemporary group is, in effect, a reference
- EPDs that are directly comparable within a breed for all individuals (males and females) in all locations and management systems across all years

EDP Traits

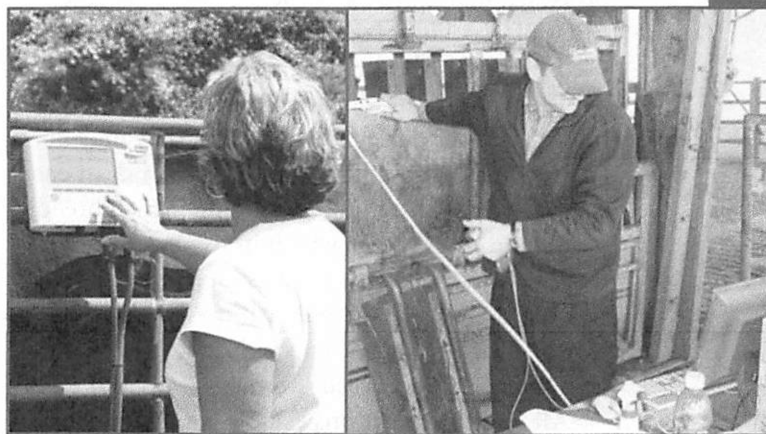
All of the breed associations that have EPD report four traits:

- **Birth Weight**—in pounds at birth, excluding maternal influence. Birth weight is the most important factor in Direct Calving Ease (see below).
- **Weaning Weight**—in pounds at 205 days of age, excluding maternal influence (evaluated as Milk below)
- **Yearling Weight**—in pounds at 365 days of age, excluding maternal influence
- **Milk**—expressed as pounds of weaning weight (not pounds of milk) due to maternal influence of an individual's daughters, excluding genetics for growth to weaning (evaluated as Weaning Weight above). The use of "milk" is inexact because this is an estimate of all maternal influences on weaning weight, milk production being the major element. Total Maternal EPD, combining Milk and Weaning Weight, also is reported by some breeds. Total Maternal should be ignored and the two components considered separately unless a producer merely wishes to increase weaning weight without regard for what causes the increase.

Other traits that may be included by a breed are:

- **Direct Calving Ease**—in percentage of unassisted births or as a ratio. This is an estimate of a calf's ease of birth, excluding maternal factors (evaluated as Maternal Calving Ease below). Direct Calving Ease depends primarily on the size of the calf. If Direct Calving Ease is available, it should be emphasized instead of Birth Weight, which only indirectly estimates calving ease.
- **Maternal Calving Ease**—in percentage of unassisted births or a ratio. It is the ease of calving of daughters excluding factors associated with the calf (evaluated as Direct Calving Ease above). This essentially involves the size, internal structure, uterine environment, and other factors of the calving female.
- **Calving Ease Total Maternal**—combines Direct and Maternal Calving Ease
- **Gestation Length**—in days; is related to birth weight, calving ease, and calving interval

- **Yearling Height**—in inches, another estimate of genetic size; a predictor, along with weight traits, of mature body size
- **Scrotal Circumference (SC)**—in centimeters; a predictor of mass of sperm-producing tissue. Also, SC is positively related to younger age at puberty in males and their female relatives.
- **Days to Finish**—in days; the length of time needed to reach a set amount of fat cover
- **Carcass Weight**—in pounds, another measure of body size that is highly related to yearling weight
- **Marbling**—in USDA marbling degrees, the primary factor in USDA Quality Grade
- **Tenderness**—in pounds of shear force; a mechanical estimate of tenderness
- **Ribeye Area**—in square inches between the 12th and 13th rib; a predictor of total amount of muscle. Ribeye area is highly related to carcass and yearling weights.
- **Fat Thickness**—in inches over the ribeye at the 12th/13th rib; a predictor of total carcass fat which is the most important factor in percentage red-meat yield (cutability)
- **Yield Grade**—in USDA Yield Grade units; a measure of cutability
- **Retail Product (RP)**—in percent; another measure of cutability
- **Ultrasound measures**—for Ribeye Area, Ribeye Fat Thickness, Rump Fat Thickness, Retail Product, and Ribeye IMF (intramuscular fat, in percent), which is a predictor of marbling
- **Mature Daughter Weight and Height**—in pounds and inches; measures of mature size of daughters
- **Cow Energy Indexes**—in dollars or units of energy; assess differences in cow nutritional energy requirements
- **Docility**—in percentage of deviation from the probability of Behavior Score being either docile or restless as opposed to being nervous, aggressive, or very aggressive.
- **Heifer Pregnancy**—in percent; the pregnancy rate of daughters when exposed to calve first at 2 years of age
- **Stayability**—in percentage deviation from a 50 percent probability of daughters remaining in the herd to at least 6 years of age. This involves all factors in culling of females, and so is thought to be related to structural soundness, fleshing ability, reproductive efficiency, and general fitness.
- **Value Indexes**—in dollars, also called economic selection indexes and $ indexes; multi-trait indexes combining relevant production EPDs with cost to produce and value of product. Various breed associations have indexes for value: 1) as weaned calves, 2) after feeding, 3) as carcasses marketed on a Quality Grade-Yield Grade price "grid", 4) with combined feeding and carcass value, and 5) for the total production cycle from conception to carcass.



Individual animal records such as weight and ultrasound measurements are necessary to provide data that make EPD possible. (Photo on left by kimberlybrianphotography.com)

Interpreting EPD

EPD values are calculated as average relative deviations, not actual levels, of the unit of measurement of the trait. Assume that one bull has a Birth Weight EPD of +4.2 and another bull of the same breed has -1.4. This means that, if used on genetically equal females managed under equal conditions, the first bull is predicted to sire calves averaging 5.6 pounds heavier at birth (the difference between +4.2 and -1.4).

As another example, if one bull has a Weaning Weight EPD of +42 and another has +27, the predicted average difference between the two bulls is 15 pounds in weight of their calves at weaning.

EPD does not predict performance level. If a bull has +4 Birth Weight, this does not predict that he would increase birth weights by 4 pounds, nor would a bull with -1 Birth Weight decrease birth weights by 1 pound. The two bulls are predicted to sire calves averaging 5 pounds difference. The actual average birth weights, depending on other factors, might be 75 pounds and 70 pounds or 95 pounds and 90 pounds or any other average difference of 5 pounds. EPD predicts **comparative** differences, not level of performance.

If the EPDs of both parents are known, they can be combined to predict the relative performance of the progeny. For example, compare a sire of Weaning Weight +55 mated to a dam of +35 with a sire of +40 mated to a dam of +30. Their progeny would be predicted to differ in weaning weight by 20 pounds (55 + 35 minus 40 + 30).

Breed associations calculate their own EPDs that are comparable only within the breed. However, EPDs of individuals of the same breed can be legitimately compared even if they are to be mated to another breed, or cross of breeds, as long as the proposed mates are the same. For example, the EPDs of two Charolais bulls can be compared for use in a herd of Brahman-cross females.

There are some adjustment factors for comparing EPDs from different breeds, but they may be less reliable than within-breed EPDs. In most cases, producers should first determine which breed(s) to use and then decide which individuals to select from within the breed(s). To assist in choosing applicable breeds, see the publication in this series E-190, *Texas Adapted Genetic Strategies for Beef Cattle V: Type and Breed Characteristics and Uses.*

All breed associations establish a base period when the breed-average EPD value for a trait is zero, and those bases differ for each breed. Selection changes genetic level over time. As time passes since the base was established, the breed average could differ increasingly from zero.

Breed averages can vary considerably. For example, recent average Yearling Weight EPD in one breed is +11 and is +76 in another breed. These breed averages cannot be compared, so the values do not mean that the second breed averages 65 pounds heavier.

Current breed averages can be used to see where an individual ranks within a breed. Maintaining a fixed base provides a benchmark that can be used to help determine the level of EPD in a breed that might be appropriate for particular production conditions. This benchmark would not be available if the breed average was reset to zero every time EPDs are recalculated.

Once or twice a year, associations update individual animal EPDs, breed averages, distribution of EPDs within the breed, and genetic trends. The most recent reports should be used and EPDs from different reports cannot be compared.

Accuracy

Suppose two individuals have Weaning Weight EPDs of +32 (0.62) and +46 (0.41). The values in parentheses are for Accuracy, which ranges between 0 and 1. (Accuracy usually is not calculated for Pedigree EPD, based only on parental EPDs, or for Interim EPD, based on pedigree EPDs plus the individual's record.) Accuracy is influenced by the number of records, genetic relationship among individuals providing the records, heritability of the trait, and number of contemporary comparison groups.

Accuracy is not related to variation in progeny. Progeny of low-Accuracy parents will vary no more, on average, than progeny of high-Accuracy parents. Also, difference in parental EPD is not related to progeny EPD variation. For example, consider a sire and dam both with Yearling Weight EPD of +60 compared to a sire with +80 and a dam with +40. On average, there is no difference in progeny variation from these two matings and both sets of progeny are predicted to average +60 EPD.

So what is more important, the magnitude of EPD or Accuracy? EPD is an estimate of true breeding value in relation to other individuals in a breed. Accuracy is a measure of confidence that the EPD is the true breeding value. If a producer wants large and rapid change in a trait then EPD should be stressed, even if Accuracy is low. But if predictability is more important, higher Accuracy individuals should be selected. Regardless of Accuracy, EPD is the best estimate available of true breeding value.

Possible Change

Over time, Accuracy increases and EPD often changes as more records relating to an individual (primarily progeny) are accumulated. Breed associations publish and regularly update Possible Change Values, which are measures of the average amount that EPD could change over time.

For a given Accuracy, about two-thirds of the time an individual should have a true progeny difference within the range of the EPD plus and minus the Possible Change Value. But about one-third of the time, the true value could fall outside that range. Therefore, "Possible Change" is another misleading term because it implies incorrectly that greater change is not possible. However, for any range of Possible Change the true progeny difference is much more likely to be toward the center of the range than the extremes.

Assume a breed reports Possible Change in Weaning Weight EPD as shown in Table 1.

Table 1. Possible Change Values for Weaning Weight EPD*

Accuracy	0.1	0.3	0.5	0.7	0.9
Possible Change	16	13	9	6	2

*This is only an example. Possible Change varies for every breed and trait.

From this table, with Accuracy of 0.3, the Possible Change is ± 13 units of the EPD. So, for example, with an EPD of +30 about two-thirds of individuals are expected to have true progeny differences between +17 and +43 (30 ± 13), sometimes called the confidence range. With Accuracy of 0.7 the Possible Change is only ± 6, so with EPD of +30 the true progeny difference is expected to be between +24 and +36. Note in the table that Accuracy of 0.9 predicts almost no change in EPD, but Accuracy this high is possible only for individuals with hundreds of progeny records. In short, higher Accuracy means greater **predictability.**

The anticipated direction of any future change is unrelated to the magnitude of the current EPD. That is, a numerically high EPD is as likely to change to an even higher value as it is to move downward. And a low EPD is as likely to change to an even lower value as it is to move upward. These considerations are taken into account in the calculations.

Genetic Potential

How much potential is there for genetic change within a breed? A good estimate can be obtained from a percentile breakdown, which shows distribution of EPD. Table 2 shows a percentile breakdown for Yearling Weight EPD and also lists the total range within the breed. With this information, a producer can determine potential for genetic change and also see where the EPD of a particular individual stands in the breed.

Table 2. Percentile breakdown for Yearling Weight EPD*

Percentile	1%	5%	20%	50%	80%
EPD	+95	+85	+68	+53	+38

*An example only. Current breed average is at the 50th percentile (+53). The total breed range is from -13 to +131.

This table shows an example of the EPD level for various percentiles. Based on the upper end of the range (+131), it would be possible to find a bull with EPD 78 pounds (131 minus 53) above breed average. However, only 1 percent of the individuals in the breed have EPDs of +95 or higher. Finding a bull just 30 pounds above average would require restricting selection to the top 5 percent of the breed. Broadening to the top 20 percent of bulls reduces the difference to just 15 pounds above average.

Although the range of genetic expression in a breed may be wide, the majority of EPDs will be near the average. But this means a producer who wants a performance level for a particular trait that is near breed average has large numbers of potential sires available. In that case, it is easier to find sires acceptable in all traits important in the herd.

Making a lot of change quickly in several traits requires unusual outlying sires. For example, a search in a breed with over 2,300 sires listed found only four in the top 10 percent for low Birth Weight EPD, high Weaning Weight EPD, and high Milk EPD. And those four sires might be undesirable in other important traits.

The fastest genetic change can be made by using superior sires from a breed noted for high expression of the trait of interest. However, other changes would probably accompany a substitution of breeds. Considering the number of factors that should be considered in sire selection, only small change may be feasible in any one trait in a short time.

Does EPD Work?

What evidence is there to confirm the theory of EPD? A recent summary reviewed research results. The first part of the study compared sire EPD with actual performance of progeny. Nine studies of growth traits involved 27 trait analyses. In 23 instances, progeny response was higher from high-EPD sires than for low-EPD sires. Five maternal studies had 14 trait analyses, of which 13 resulted in higher response from cows whose sires had high EPD for maternal traits. And four carcass studies included 23 trait analyses; in 16 of these the response was higher from high-EPD sires.

In the second part of the review, progeny response was regressed on what was predicted from sire EPD. For growth traits there was an average response of 1.03 pounds in progeny for each 1.00 pound of sire EPD. In maternal traits the response averaged 1.45 to 1.00. And for carcass traits the response averaged 1.04 to 1.00.

In conclusion, the review of available research confirmed that EPD is a valid and useful estimate of true breeding value for growth, maternal, and carcass traits.

Using EPD

Suppose four producers are looking for sires of a particular breed. All four producers have used sires of this breed before in their herd.

- **Producer A** has F1 Brahman-cross cows weighing 1,200 to 1,400 pounds in moderate body condition. Calves are often retained through the feeding phase. All replacement females are purchased.
- **Producer B** has a group of yearling heifers to breed. All calves will be sold at weaning. No replacement heifers will be saved.
- **Producer C** sells at weaning and wants to increase weaning weights but not cow size. Cows

usually stay in good body condition without much supplementation. Replacement heifers are saved to go back into this herd.

- **Producer D** saves heifers to go back into the herd and feeds out some calves. The producer is generally satisfied with current levels of calving ease, weaning weight, and postweaning performance.

Potential sires are shown in Table 3. For reference, the current breed-average EPDs are shown. Which of these potential sires should be selected?

Table 3. Selecting a sire using EPD

Sire No.	Birth EPD	Weaning EPD	Yearling EPD	Milk EPD
1	-1.3	+15	+39	+4
2	+4.7	+42	+81	-2
3	+2.5	+34	+56	+13
4	+1.9	+28	+47	+22
Breed average	+2.1	+30	+51	+12

- **Producer A** would benefit most from growth potential, so long as carcass weights are not excessive. Milking ability is irrelevant, since replacements are not saved. With large Brahman-cross cows, calving difficulty (predicted from Birth Weight EPD) is of little concern. Therefore, the best choice is probably Sire 2, which is highest in Weaning and Yearling Weight EPDs.
- **Producer B** should give primary consideration to calving ease. Sire 1, with the lowest Birth Weight EPD, is the best choice for that purpose. Although Sire 1 is lowest in Weaning and Yearling Weight EPDs, in this case growth potential is secondary to calving ease. And no replacement heifers are saved, so Milk EPD is not a factor.
- **Producer C**, to increase weaning weight but not cow size, appears to need increased milk production in heifers going back in the herd. The body condition of the herd indicates that higher milking ability can probably be supported on existing production conditions. Sire 4, highest in Milk EPD and around breed average in Birth, Weaning, and Yearling Weight EPDs, is probably the best choice.
- **Producer D** does not seem to need significant change in any of these traits. Sire 3 is near breed average in Birth Weight and Milk EPDs and a little above average in Weaning and Yearling Weight EPDs. This is probably the best choice for this producer.

The best choice depends on the particular herd and what is needed from the sire. Many other production traits are important besides the four discussed above that are common to all breeds reporting EPD. Where EPD is available for other important traits, it should be the primary selection criterion for that trait. For traits without EPD, other valid measures of comparison should be used.

Production conditions and markets dictate appropriate levels of animal performance. For example, where forage is sparse or low in quality, mature cow size or milking potential may need to be moderated. Producers with experience using particular breeds in their production conditions have a better idea of appropriate levels of EPD within those breeds.

Summary

EPDs can be directly compared for all animals (male and female), from all locations and management conditions, across all years, within an entire breed. For the traits where available, EPD is the most accurate estimator of true breeding value.

For further reading

To obtain other publications in this Texas Adapted Genetics Strategies for Beef Cattle series, contact your county Extension office or see the Extension Web site http://AgriLifeBookstore.org and the Texas A&M Animal Science Extension Web site http://beef.tamu.edu.

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Texas Adapted Genetic Strategies for Beef Cattle VII: Sire Types for Commercial Herds

Stephen P. Hammack*

Choosing types of sires is one of the most important decisions for beef producers. That choice should depend on:

- Climatic, management, and market conditions
- Number of production phases
- Breeding systems
- Types and breeds of cows in the herd
- Characteristics of sire types and breeds that complement the factors above

Producers need to assess the production conditions accurately to make sure that they are compatible with the potential for genetic production. The genetic considerations for herds marketing at weaning should differ from those for marketing on a value-based carcass grid.

For a discussion of the two primary genetic factors, see the Texas A&M AgriLife Extension service publication *Texas Adapted Genetic Strategies for Beef Cattle III: Body Size and Milking Level.*

Breeding systems are crucial factors in choosing types, breeds within types, and individuals within breeds. There are two basic commercial breeding systems:

- **Continuous systems,** in which females from the herd are retained for breeding. These systems should use types and breeds that are similar and, in general, have moderate levels of production for primary characteristics.
- **Terminal systems,** which do not retain females. Terminal systems can use dissimilar sire and maternal types.

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Texas Adapted Genetic Strategies

For more information, see *Texas Adapted Genetic Strategies for Beef Cattle IV: Breeding Systems.*

To produce efficiently, the types, breeds, and individuals must be compatible with production conditions and breeding systems. Most cattle can be categorized by genetic classification as Bos taurus (non-humped) or Bos indicus (humped, also called Zebu) and by breed averages for body size (weight), milking potential, and body composition.

Until recently, it was relatively easy to group the major breeds based on differences in these characteristics. But body size and milking potential are now more similar among many of the major breeds than previously, especially when the Continental European breeds were first introduced and the British breeds had not started genetic selection to increase size and milk.

Even so, the traditional functional types are still a logical starting point for designing an adapted breeding program. Below are the types and most numerous breeds listed alphabetically within type:

- **British Beef:** Angus, Hereford, Red Angus, Shorthorn
- **Continental Beef:** Charolais, Chianina, Limousin, Maine-Anjou
- **Continental Dual Purpose:** Braunvieh, Gelbvieh, Salers, Simmental
- **Dairy:** Holstein, Jersey
- **Bos indicus:** Brahman
- **American** (part Brahman base): Beefmaster, Braford, Brangus, Red Brangus, Santa Gertrudis, Simbrah
- **Specialty:** Breeds varying widely in characteristics, so they cannot to be placed logically in any of the above groups

Bos taurus and Bos indicus were combined to create an intermediate type, the American breeds. Recently, some of the Continental and British breeds listed above have been combined to create intermediates to those types. The more numerous of those combinations (and their registry association) in Texas include Beef Builder (Braunvieh), ChiAngus (Chianina), Balancer (Gelbvieh), LimFlex (Limousin), MaineTainer (Maine Anjou), Optimizer (Salers), and SimAngus (Simmental).

Also, some American or Bos indicus have been combined with British or Continental to decrease the percentage of Bos indicus. Of these, the more numerous in Texas include Angus Plus (Red Angus), Advancer (Beefmaster), UltraBlack and UltraRed (Brangus), Southern Balancer (Gelbvieh), and SimAngus HT (Simmental).

Producers should estimate from the proportions of their constituent breeds the functional characteristics and therefore best uses in commercial herds of these new intermediate combinations.

For a more complete discussion of breeds, see *Texas Adapted Genetic Strategies for Beef Cattle V: Types and Breeds, Characteristics and Uses* and *Texas Adapted Genetic Strategies for Beef Cattle VI: Creating Breeds.*

Producers who market at weaning via traditional methods often are subject to biases and visual perceptions that may reduce prices unjustifiably, especially for new breeds, unusual breeds, and their crosses. In Texas, traditional producers can avoid or minimize price discounts, while maximizing production efficiency in their environments, by producing medium- to large-frame calves that are at least 1/4 British, no more than 1/2 Continental, and no more than 1/4 Bos indicus. For high-quality markets, use higher percentages of higher-marbling British breeds. For lean-beef markets, use higher percentages of Continental.

Prices differ somewhat even within these ranges. These differences change over time in the exact percentages favored, and the variations are usually smaller and shorter term than for cattle outside these ranges.

Some combinations not generally preferred as stocker-feeders may be a logical choice for replacement females, particularly 3/8 to 1/2 Bos indicus. In Texas and much of the southern United States, part-Bos indicus cows have advantages too important to ignore, including longevity, calving ease, maximum hybrid vigor, and climatic and forage adaptability. Also, bulls with some Bos indicus genetics are better adapted to tropical or subtropical environments.

Traditional cow/calf producers marketing at weaning should heed the preferences of their marketing systems while emphasizing biological and economic efficiency to weaning. To increase revenue, document genetic merit and market it to the buyer or, better yet, retain ownership through finishing and market on value-based carcass grids.

Otherwise, the performance of market calves beyond weaning and their eventual carcass merit are of no economic importance to these traditional producers and should not influence decisions on selection of sires.

Following are the most applicable sires for commercial cow herds:

British cows: Although straightbred British cows can be bred to the same breed of sire to produce straightbred calves, such calves lack hybrid vigor. Also, some straightbreds incur price discounts.

To produce progeny such as Angus-Hereford "black baldies," cross within the British breeds. If you save heifers and want to add limited amounts of Continental genetics in the cow herd, use Continental-British intermediate sires. Continental sires can improve USDA Yield Grade and, in some cases, weight gain.

American sires add a "touch of ear" for either stocker-feeder marketing or some replacement female buyers. American-British intermediate sires would create even less "ear."

Brahman sires (not recommended on heifers) produce the highly regarded Brahman F1 female. To fully capture their market potential, develop Brahman F1 females at least to breeding age. Prices for half-Brahman steers will probably be discounted.

The main cautions with British cows are 1) avoid low-calving-ease, high-birth-weight sires and 2) don't produce straightbreds that are price discounted in your area.

Straight Bos indicus cows: For commercial production, straight Bos indicus cows should be used most logically to produce F1 replacements. For this purpose, Hereford sires are most often used or, less frequently, Angus.

Do not use Bos indicus or American sires on straight Bos indicus commercial cows because the calves will be significantly discounted for being over half-blood. You might use Bos indicus sires to create straightbred commercial Bos indicus females for crossing to produce F1 females; however, the price of straightbred Bos indicus stockers or feeders will be severely discounted.

Part Bos indicus cows: This includes true F1 or other part Bos indicus, including cows of the American type. Terminal crossing can apply using Continental, Continental-British intermediate, or British sires, which also would reduce Bos indicus percentage in any females retained for replacements if the producer so desires.

American sires are appropriate (including for straightbreeding) to maintain 3/8 to 1/2 Bos indicus replacements (especially for hot and humid conditions) unless the cows are more than 1/2 Bos indicus; however, stocker/feeder progeny are usually somewhat price discounted. Using American/Bos indicus-British/Continental intermediate sires reduces the percentage of Bos indicus more than does using American sires. To avoid significant price discounts in stocker/feeders, do not use pure Bos indicus sires on part Bos indicus cows for commercial production.

Part Continental cows: British sires produce desirable slaughter offspring and can be used for female replacements. American sires add some Bos indicus background for hot-climate adaptability as would, to a lesser degree, American/Bos indicus-British/Continental intermediate sires. Continental-British intermediate sires maintain higher levels of Continental than do British sires.

In general, avoid using Continental sires on part Continental cows, except when targeting the lean-beef market, as visibly high-percentage Continental calves may be price discounted. Also, high-percentage Continentals may not be as useful for brood cows as they might milk excessively and/or be too muscular (possibly leading to low body condition and reduced reproduction) for many Texas pasture and range conditions.

First-calf heifers: The most applicable sires are documented individuals of known calving ease, which is most influenced by birth weight. Such sires are most easily found in smaller individuals from British breeds, small dairy or dual-purpose breeds, and some specialty breeds, especially Texas Longhorn. An unsupported claim of "calving-ease bull" is often worthless.

Do not reduce birth weight to extremes below than needed for calving ease because it may unnecessarily reduce calf sale weight and, with some easy-calving breeds, market price.

When choosing a commercial beef sire, avoid:

- Calving difficulty
- Body size and muscling that are too low or too high for production efficiency and market desirability
- Milk production that is too low or too high for production efficiency
- Levels of Bos indicus that are too high for acceptable market calf value

Many genetic combinations will avoid these problems and result in the optimum, most profitable production.

For further reading

To obtain other publications in this Texas Adapted Genetic Strategies for Beef Cattle series, contact your county Extension office or visit the website of the AgriLife Extension Bookstore (http://agrilifebookstore.org) or the Texas A&M Animal Science Extension (http://beef.tamu.edu).

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