Managing Pasture Fertility

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Pasture fertility is about much more than just applying N-P-K fertilizer. Pastures have the same need for regular soil testing and maintenance of basic fertility levels as cropland, but they are more complex to manage than simple hay fields because of the animal factor. Two of the great benefits pastures have compared to cropping system are perennial and annual legumes to fix atmospheric N and recycling of nutrients through dung and urine. Grazing management has a lot to do with the relative effectiveness of these two processes.

Soil sampling and testing for pastures: Soil sampling in pastures requires a more thoughtful approach than crop fields. Animals redistribute nutrients based on grazing and rest patterns. Some things to consider are locations that favor animal concentration are likely to be much higher in nutrients than the general pasture area. Stock water sources, shade, and mineral or supplement feeding areas should be avoided when taking soil samples. Plan to stay at least 100 ft away from any of these sites.

A minimum of 20 cores should be taken for each sample. Thirty to forty is better. Besides the large scale nutrient gradients described above, there are also microsite variations due to dung and urine deposition. Some of the older pasture fertility literature recommends avoiding any obvious dung pile, both old or new. This is based on typical manure distribution with continuous grazing where less than 2% of the pasture surface area is affected by dung piles in any given year. Hitting a few manure piles in continuously grazed pastures can seriously skew the soil sample.

In modern high stock density grazing, a much higher percentage of the soil surface is affected by dung piles every year. Some studies have shown as much as 50% of the soil surface being covered with manure. Avoiding manure piles in this situation leads to an underestimate of nutrient status. In high stock density pastures, it is better to sample on a set spatial interval to get an accurate representation of soil nutrient status.

Some pasture specialists advocate testing for all the necessary micronutrients for plant growth. This can become very expensive very quickly. Getting a few samples with the full spectrum of essential nutrients can be helpful for establishing some baseline conditions in your pastures, but getting full analysis on all samples is probably not cost effective. If there are known nutrient deficiencies in your area, get a test for those specific nutrients. If no soil, tissue, or animal test in your region has ever shown a deficiency of a particular nutrient, the likelihood of you experiencing a problem with that nutrient is very remote. Don’t waste your money.

By the same token, blanket recommendations for micronutrient applications are generally unrealistic and potentially dangerous. Nutrient status in the soil is closely tied to parent material, age of the soil, and past use of the field. Opposite sides of a mountain valley can have very different nutrient profiles. One farm to the next can be quite different depending on past cropping or grazing history. The fertility program that works best on your farm is the one based on your soil tests and interpreted for your objectives. You can spend a lot of money on micronutrients that provide no improvement in pasture yield, quality, or persistence.

Tissue testing for minerals is another tool that can be used to fine tune fertility management where needed. One of the great challenges of tissue testing is the level present in the plant fluctuates with season and plant maturity. If you are using tissue testing make sure you fully understand the implications of the results obtained.

Nitrogen management: Nitrogen is usually the first limiting nutrient in most grassland ecosystems. To keep pastures producing, there must be a near continuous supply of N. This N can come from the organic fraction of the soil, legume fixation, dung and urine recycling, atmospheric deposition, applied manure, or applied fertilizer. Obviously the latter two have a higher cost than those that can be considered 'natural' cycles.

Can a productive pasture system operate without external N inputs? On our grass farming operation in Missouri, we applied N fertilizer on just three occasions in the 22 years we operated the farm. Each time it was on fewer than 20% of our pasture acres and was for a very specific reason. All the rest of the time we relied on legume fixation and nutrient recycling. Our carrying capacity was twice what most of our neighbors using N fertilizer were able to achieve. Numerous studies have found well managed legume-based pasture systems to have similar or superior carrying capacity as pastures receiving moderate levels of N. Individual animal performance is usually higher on grass-legume systems compared to the same grass receiving N fertilizer.

For an effective legume-based N supply, pastures should maintain a 30-50% legume component. Lower legume presence will lead to chronic N deficiency in the pasture and disappointing production. Too much legume can increase bloat risk, reduce soil resistance to compaction and erosion, create an energy:protein imbalance in the rumen, as well as other problems.

Maintaining legumes in this range is one of the ongoing challenges of pasture management. Legume content of the pasture is affected by soil fertility level (including N level in the soil), canopy management, and reseeding strategies. The higher pH and other nutrient requirements of legumes are well documented and widely understood among producers. Canopy management and reseeding are less well understood.

In general, shorter grazing residuals favor legumes while taller residuals favor grasses. A simple illustration of this is heavily stocked pastures frequently increase in legume content while lightly stocked pastures decline. Many legumes need sunshine at the plant crown to stimulate regrowth. Carbohydrate storage in tap roots reduce the need for residual leaf area with some legumes. Both of these traits allow legumes to regrow more rapidly following close grazing. Most grasses rely on residual leaf area for regrowth, hence the need for greater residual leaf area.

Many producers dislike red clover because it must be reseeeded every few years to maintain a stand. The same producers are willing enough to go out and apply N every year. Overseeding a small quantity of red clover seed every year greatly increases the year-to-year consistency of red clover production at a fraction of the cost of N fertilization. It is simply a question of what you are willing to do for pasture management. Birdsfoot trefoil and many clovers can be maintained through natural reseeding with appropriate summer rest management.

While the daily input of N and other nutrients is low with continuous grazing, high stock density grazing deposits surprisingly high amounts of N per acre making the natural nutrient cycle much more effective in driving forage production.

So what is the role of N fertilizer in pasture finishing systems? In my view, N fertilization is a tool to be used when targeting very specific goals. Using annual ryegrass as a fall finishing pasture is a good example. The residual N level in the soil may be low if the ryegrass is going on cropland. This is a time to use N fertilizer and get a good payback on the expense with the high productivity of annual ryegrass and excellent animal performance. Tifton 85 bermudagrass is another example. This grass is very responsive to N, has high enough summer quality for finishing, and there are few legume options available in the humid South that would even begin to provide the necessary N. Specific situations with specific goals.

The power of stock density: Stock density is the most powerful in the grazier's toolbox when it comes to managing an effective nutrient cycle. High stock density greatly increase the amount of area affected by dung and urine in every grazing cycle. Whereas nutrient deposition under low stock density as in continuous grazing barely feed the soil microbes, the nutrient distribution rate is high enough with stock densities over 40,000 lb/acre actually feed the plants.

Table 1. Effect of stock density and protein content of forage on readily available N applied to pasture through grazing based on a daily intake rate of 2.6% of body weight. (Urine N only)

Protein content	**Stock Density (lb animal liveweight/acre)**						
	600	1200	4800	24000	48000	96000	192000
	------------------------------------ *(lb available N/acre)* ----------------------------------						
10%	0.1	0.2	0.9	4.7	9.5	19.0	38
15%	0.2	0.5	1.9	9.5	19.0	37.9	76
20%	0.4	0.7	2.8	14.2	28.5	56.9	114

This table only includes readily available N from urine. There would be additional slowly released N from dung at a level approximately equal to that shown for the 10% protein level. Bottom line is high stock density grazing can apply meaningful levels of fertility at every grazing.

Summary: Understanding and managing natural plant-animal-soil processes can greatly reduce your reliance on purchased fertilizers. Use soil testing to determine your basic needs and then manage your pastures to maintain fertility levels through effective nutrient cycling. Legumes are a critical part of the pasture ecosystem so make sure you are effectively managing soil fertility, canopy competition, and reseeding to maintain the target level of legumes between 30-50%.

Irigated Pastures for Grass-Fed Beef
"Managing Irrigation for a Quality Product"

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Irrigating pastures for grazing livestock is rapidly becoming an alternative method of providing additional grazing opportunities in a livestock enterprise. The value of irrigation of a grass pasture is simply to provide adequate moisture for grass growth at the appropriate time. For grass to grow, the soil must have adequate moisture at the same time that the correct temperature for grass growth is occurring. Both of these conditions must occur simultaneously. What we don't always get is adequate rainfall when the plant needs it. Irrigation simply provides this moisture to the grass crop when needed.

Reasons for irrigating pastures

As a grass-fed beef producer, the incorporation of some irrigated pastures is extremely important. It can increase your total available pastures to meet current needs. It can provide a higher quality forage. It reduces food costs. It can compete economically with most commodity row crops. It allows you to convert erodible crop land to reduce negative impacts to the environment. It improves ground water quality. It allows you to extend your grazing season. It gives you the chance to concentrate your livestock into a smaller grazing area for easier management. It can improve the profit potential of your current irrigated crop land. But most important, it can extend the length of the grazing season that will produce high quality grass fed beef.

Types of forage

The types of forages that you use will depend on the goals that you may have and on the time of the year you plan to graze the forage. Choose among long term perennial forages, short term forages, or even between annuals and biennials. Long term perennial forages can last 20 years or longer. Short term perennial forages are expected to survive for three to five years, generally are quick to establish and are usually of higher quality than the longer growing species. Biennials and annuals may have a place in a grazing system to fill voids and gaps in the grazing season.

Select between cool and warm season grasses. In the cooler regions of the country, cool season grasses respond more fully to irrigation than do the typical warm season grasses. They also respond more quickly to applications of water and fertilizer. Research has shown that mixtures of several cool season grasses will usually outproduce single species. Most warm season grasses complete most of their annual growth in a short period of time, and therefore do not fully utilize an irrigation system.

Consider the inclusion of legumes in the grass mix. Legumes will increase the total forage production of the pasture. Also, the nitrogen fixing properties of the legumes can somewhat reduce the nitrogen fertilizer requirements. They can, however, create challenges with respect to bloat management, weed control, fertilizer, and irrigation management. Table 1 lists some examples of grasses and legumes that respond to irrigation.

Planting guidelines

Perennial pastures can be established either in the spring or in the fall. Fall establishment is generally recommended. Germination is quicker and more uniform than spring seeding. Weed problems are reduced compared to spring planting.

Spring planting should occur as early as possible in the spring to allow as much early growth as possible. Fall planting is ideally done from early August in the northern states to late September as you go south. About 45 days is necessary prior to a killing frost is important for good establishment. Later fall planting is risky when an early winter occurs and the plants are not well enough established. Legumes take longer to establish and are at the higher risk in late fall plantings.

In areas where fall rains are spotty and not dependable, establishing grass seed in non-irrigated pastures is risky because of the general lack of adequate moisture. This is not the case in irrigated pastures. Fall seeded pastures should be irrigated frequently after planting and until cold weather stops the growth of the seedlings. Irrigate with small amounts of water per application.

Approximately 1/3 inch of water per application is sufficient. Total applications may be from five to 10 times, depending on current weather conditions.

The seedbed should be very firm. Good seed-to-soil contact insures proper germination. If drilling, plant 1/8 to 1/4 inch in depth for the grasses. Legumes should also be planted very shallow, or spread in top of the ground. Some producers spread seed on top of the ground and then press the seed into the soil with a roller-packer operation.

The three most common mistakes that can be made in fall planting cool season grasses are (1), planting too deep; (2), having too soft a seedbed; and (3), not watering often enough. Don't depend on the weatherman to help you. Just keep watering <u>until</u> it rains, rather than waiting for the shower the weatherman says is coming.

Fertilization

Proper fertilization is essential for successful production from irrigated pasture. Irrigated cool-season grasses have been found to continue to respond to nitrogen (N) at rates as high as 200 to 250 lb/acre. The level of fertilization that is used should consider the level of forage production or stocking rates that are desired, as well as fertilizer costs (Table 2). Split applications of N fertilizer are most efficient. The most efficient use of nitrogen fertilizer

Table 1. Grasses and legumes that can show a response to irrigation

Forage	Growth Form	Seeds per Pound	Seeds/sq. ft. when seeded at 1 lb/acre	Recommended seeding rates when seeded alone (lb/acre)[2]
Cool season, long term grasses				
Smooth bromegrass	sod-forming	134,000	3.0	8 - 12
Creeping foxtail	sod-forming	750,000	17.2	2 - 3
Reed canarygrass	sod-forming	550,000	12.6	3 – 5
Intermediate wheatgrass	sod-forming	88,000	2.0	12 - 16
Pubescent wheatgrass	sod-forming	100,000	2.3	10 - 14
Perennial ryegrass	bunchgrass	228,000	5.2	6 - 10
Orchardgrass	bunchgrass	590,000	13.5	4 - 6
Meadow brome	bunchgrass	90,000	2.1	12 - 16
Timothy	bunchgrass	1,230,000	28.2	2 - 3
Tall fescue	bunchgrass	228,000	5.2	6 - 10
Cool season, short term grasses				
Perennial ryegrass	bunchgrass	228,000	5.2	15 - 30
Matua prairiegrass	bunchgrass	70,000	1.6	25 - 30
Meadow fescue	bunchgrass	227,000	5.2	8 - 12
Legumes				
Alfalfa	- -	210,000	4.8	12 - 18
Red clover	- -	275,000	6.3	5 - 7
White clover	- -	802,000	18.4	3 - 5
Alsike clover	- -	680,000	15.6	3 - 4
Birdsfoot trefoil	- -	375,000	8.6	7 - 10
Kura clover	- -	800,000	18.4	5 - 6
Warm season perennials				
Eastern gamagrass	bunchgrass	6,000		8 - 10
Bermuda grass	sod forming	(sprigs)	- -	- -
Annuals and bi-annuals				
Annual ryegrass	- -	224,000	5.1	20 - 30
Italian ryegrass	- -	227,000	5.2	25 - 35
Corn (maize)	- -	1200 - 2000	- -	- -
Oats	- -	15,000	- -	100 - 200
Rye	- -	18,000	- -	75 - 150
Triticale		14,000	- -	75 - 150
Turnips/brassicae	- -	167,000	3.8	5 - 6
Crabgrass	- -	800,000	18.4	1 -5

suggests most to be applied in the spring with the remainder during the summer and fall. Because spring growth of cool season grasses are most prolific, higher nitrogen fertilizer levels in the spring can exacerbate the problem of over production. Therefore, I would recommend applying minimal amounts of nitrogen in the spring, providing only enough nutrients to encourage early growth. Then follow up with frequent applications during the growing season to match the amount of dry matter production needed and utilized. If the nitrogen can be applied through the sprinkler system, applying from zero to 30 lbs per water application, depending on need, is advised.

Table 2. Suggested nitrogen rates for irrigated pasture (from Rehm and Knudsen, 1973).

Desired stocking Yearlings/acre	Pounds of nitrate-nitrogen/acre in the soil to 6 feet: 0 – 50	50 – 100	100 – 150
	Nitrogen application (lb/acre)		
3	180	120	80
4	240	180	140
>4	270	240	200

Irrigation techniques

Irrigation water for permanent pastures can be applied in any form. The use of center pivots is the most popular. However, we see producers using solid set, movable towline, traveling guns, and gravity flow.

Center pivots are the most common method of irrigating pastures. Graziers are either converting existing center pivot farmland to pastures or installing pivots on both new and existing pastures. Center pivots are used on fields as small as 40 acres and up to 500 acres. The most common size is 134 acres that fully covers a one quarter section of land except for the corners. When center pivots are used on smaller acres, the initial cost per acre is higher. Occasionally a full sized pivot will be installed on an 80-acre field and is run only half way, then reversed in a "windshield wiper" motion. Most full sized pivots (1/4 section) need at least 500 to 600 gal/min for efficient operation. Commonly, they will operate at about 1000 gal/min in the system.

A new sprinkler system called line-pods has recently been introduced to U,S. graziers. Developed in New Zealand, the system is a series of small sprinklers connected in a line by a flexible pvc-type pipe. Each sprinkler is contained in a protective pod as the line is often in the same paddock as the livestock. Each sprinkler can deliver between one and five gallons per minute in 50 foot radiuses. Each line is connected to an underground water line. Each line is moved once or twice daily with a four-wheeler. A line of 10 or 12 pods is capable of irrigating eight to 10 acres. The system can be engineered to fit on any size and shape pasture. Initial costs are usually lower than a center pivot, but labor is higher. The energy used by this system is less than that used by pivots. This is because less pressure is needed to operate the line-pod system. Currently there are two manufacturing companies selling this system in the United States. They are K-Line and Irripod. Additional information on each of these is found on the internet.

Solid set systems are usually too expensive to install. Flood irrigation will be poor in water use efficiency. Not much work has been done using high volume big guns, and they may cause some soil compaction due to the water droplet size. Underground drip lines have been talked about, but no work has been done to this point with grass pastures for grazing.

Irrigation is used to supplement rainfall. Regular applications of ½ to 1 inch of water every 5-6 days may be ideal. Most areas of the country do not get this regular rainfall. Analyzing your financial resources, land base, and current irrigation methods will help to determine the most efficient method for your operation.

Most of the cool season grasses that are planted for irrigation are relatively shallow rooted. It is important to apply smaller amounts of water per irrigation than you would if you were irrigating row crops. I suggest about 3/4 inch per application. This will vary according to the water-holding capacity of your soil. When irrigating a new planting, reduce the amount to 1/3 inch per application until established.

You will probably use more water during the season for pasture when compared to corn or soybeans, but similar to alfalfa. Research at the University of Nebraska has shown that a typical cool season grass/legume pasture will need about 35 inches of moisture (both rainfall and irrigation) for maximum production. This generally means about 15 to 18 inches of irrigation water is needed. Some warm season grasses such as bermuda grass have a higher requirement with some producers using up to 40 inches during the growing season.

Some work done in New Zealand has shown that soil moisture should be maintained between 50% and 90% soil capacity. There is little controlled research to back this up. If the grass is allowed to reach the wilting point (soil moisture below 50% capacity), grass growth rate is slowed and total season production can be negatively impacted. For best results, I suggest starting to irrigate at the time the grass begins to grow in the spring if there are insufficient rains.

Efficient use of applied water is highest when the particular grass specie being irrigated is growing at its highest rate. Applying water to cool season grasses in the heat of the summer will cause the plants to continue growing. With insufficient water, cool season plants tend to go dormant during this time. Although the amount of water per unit of production is higher during the summer months, it is often profitable to continue watering. When the cost of water and fertilizer needed to maintain an adequate growth rate is excessive, some producers will cease watering (and grazing) during this time to conserve energy costs. This is also a useful technique when the total amount of the season's irrigation water is limited. When this occurs, it is best to maintain a small amount of irrigation to keep the grass plants from dying until temperatures begin to fall and normal growth resumes.

Fences and stock water

Fencing and water systems are similar for any grazing system. A good perimeter fence is essential to keep your livestock from wandering to the neighbors. Cross fences to establish paddocks within the pasture should be minimal in design. Any wire can be used. Galvanized high-tensile wire gives the best service and can withstand having the pivot wheels run over it. Polywire or tape can be used for a temporary fence, especially for daily moves. Nonconductive posts such as fiberglass are economical to use. A good low-impedance energizer is necessary to make this type of fencing a deterrent to the livestock.

A separate water source from the pivot or irrigation system is necessary. Water lines can be established in a variety of ways. They can be buried or lay on top of the ground. It is preferred to have water available for each paddock rather than constructing lanes to a single water source. When the water source is within 700 feet of any place in the paddock, cattle will come to water individually, rather than as a group, and smaller tank sizes can be used. It is common to move small water tanks from paddock to paddock when paddock size is as described.

Grazing management techniques

Several management techniques are worth considering with your irrigated pastures. The use of high stock density with frequent moves and short grazing periods will result in more uniform use of the available forages. It will also provide more even distribution of the urine and manure across the pasture. (Realize that 80-85% of the consumed nutrients are returned back to the soil.)

Maintain enough residual leaf area to provide for maximum recovery. Depending on the grass specie, this height can range from three to eight inches.

Appropriate rest or recovery periods are essential to maximize quality and quantity of the forage produced. This time can vary from 20 to 40 days. Too short of a rest period will not allow sufficient dry matter production to take place. Resting too long may reduce the quality of the quality of the forage.

A minimum of five or six paddocks will allow reasonable rotations. It takes at least 12 paddocks to begin to impact high utilization of the total forage produced. Approaching 25 to 30 paddocks will allow daily moves with sufficient recovery time.

Managing for highest utilization of forage produced will usually provide the highest gains per acre from your pasture. It can, however, lower daily animal gains because it reduces the opportunity for selective grazing. Your operational goals will help you reach the correct midpoint between gain per acre and daily gains per day.

Growth of irrigated cool season pastures is very rapid during spring and early summer and then slows during the warmer part of the summer. To manage this change in growth rate, reduce the number of livestock after the rapid growth period or to have additional pasture available during mid- to late-summer. An option would be to cut hay from some of the paddocks.

Expected production

Expected production can have a wide range, depending on selected forages, growing season, and management intensity. Irrigation is a tool to eliminate the variability of available moisture for growth.

Stocker gains have been reported as high as 1500 pounds per acre on cool season, irrigated pastures in the Midwest. Many are not that high. Producers should expect around 1000 pounds gain per acre with reasonable success. Research conducted in North Platte, Nebraska in the 1970's produced over 1000# gain with yearling steers and weaned calves.

As per/acre gains increase, expect to see a decrease in average daily gains of the stockers. If you are trying to maintain at least 1.8 to 2 pounds daily gain for grass fattening steers, per/acre gains may be somewhat below the 1000 pound goal. When growing commodity steers, as compared to those being grown for grass finishing, per/acre gains need to be higher to offset the lower value of each pound gain. When corn prices are around $2.50 per bushel, feedlot close-out costs may run $0.50-$0.55 per lb. gain. To compete, pasture's gains could be in the $0.45 range. At 1000 lb. gain per acre, this is a gross income of $450. Gains for grass finishing animals should be worth considerably more than commodity steer gains.

Pastures with cow/calf pairs running for the summer can expect about 300 cow days per acre. With summer pasture rental rates about $1.40 per cow/calf pair per day, the gross income would be $425.00.

Annual cost of production will vary. Each operation should calculate all costs of annual operation including establishment costs. Table 3 shows variable costs of establishment for a cool season, perennial pasture on a 1/4 section field.

Table 2. First year establishment costs for a 134 acre pivot.

	Per Acre	Total
Seed and drilling costs	$50 - 60	$6700 - 8040
Fertilizer and fall irrigation	20 - 25	2680 - 3350
Perimeter fence, 4 wire high tensile	25 - 30	3350 - 4020
Cross fencing, 12 paddock design	30 - 35	4020 - 4690
Livestock watering system, 4 water points	20 - 50	2680 - 8040
Total	$145 - 200	$19430 - 28140

To determine total annual costs per acre, consider the above establishment costs along with irrigation costs, fertilizer, labor costs, and management and overhead. Also, include land costs, whether owning or renting. The following table summarizes an example of these costs:

TOTAL ANNUAL COSTS

Establishment costs, amortized 20 years	25	
Irrigation application, 18 inches		125
Fertilizer, 150# N @ .42		64
Labor, maintenance and moving		12
Overheads	4	
Management	20	
Land, taxes, insurance	110	
TOTAL		$360

When determining the economic advantage of converting row crop acres to irrigated pastures, comparing the costs per unit of production with typically grown crops is helpful. The following table is a comparison of growing corn, soybeans, or alfalfa on a "benchmark" farm in Nebraska. This data is compiled by the University of Nebraska, Agricultural Economics Department. The complete data can be found on the web by typing "Nebraska Crop Budgets 2006" into your web browser. http://www.ianrpubs.unl.edu/epublic/live/ec872.pdf.This form allows you to use your own values to change the total costs to reflect your operation.

In summary, it is evident that there is a cost to irrigating pastures. A producer must have a legitimate reason for adding this cost to his program. He must be prepared to contribute the management skills necessary to optimize the increase in animal production needed to offset this increased cost. As a grass-finished beef producer, you have learned that it is difficult to grow and fatten your animals on a year-round basis. Many times, your current forage chain has gaps that limit daily gains. There is a new set of rules than those we use to graze commodity beef. Irrigating forages is a valuable tool to help you meet the goals to produce a quality product. You will probably use both perennial and annual forages in your forage chain to meet those goals. You have learned to think outside-the-box when you started your grass-finished beef enterprise. Continue to do so as you add irrigation to your operation.

NEBRASKA 2001 CROP BUDGETS

Pivot --- 800 gpm; 35psi	cost	breakeven
190 Bu/ac Corn, 13 acre inches	$573	$ 3.02
58 Bu/ac Soybeans, 6 acre inches	$305	$ 5.26
5 Ton/ac Alfalfa, 16 acre inches	$448	$89.60
10 AUM's/ac Pasture, 18 acre inches	$381	$38.10
12 AUM's/ac Pasture, 18 acre inches	$381	$31.75
800# gain/acre Pasture, 18 acre inches	$381	$ 0.48
1000# gain/acre Pasture, 18 acre inches	$381	$ 0.38

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Wintering Performance and How It Affects Carcass Quality

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Introduction

Environmental variation undoubtedly can have the most significant impact on livestock performance in forage based production systems. Fluctuations in temperature and precipitation influence herbage production and quality, maintenance requirements and intake. Feedlot finishing systems are driven not just by an abundance of feed grains in countries where utilized. From an economic standpoint, reduction in diet variability provides consistent animal performance and input costs. Producers of "forage system" products have much less control over animal diet and performance during it's lifetime due to environment, harvest windows of grazed and stored herbage, and the inherent lower energy density of forage versus grain/forage diets. Knowledge regarding the impact of animal performance during critical phases of production on end product would have significant impact on planning capabilities and economic returns in all production systems. A multi-year, multi-institution research effort within the "Pasture-Based Beef Systems for Appalachia" research project was directed to study the impact of winter stocker growth rate on subsequent animal performance during finishing, and beef quality in forage- and feedlot-finished beef. The research consortium involves over 30 scientists and the following institutions: USDA-ARS, Virginia Polytechnic Institute & State University, West Virginia University, Clemson University and the University of Georgia. The material presented has been previously submitted to the Journal of Animal Science for publication.

Methods

Over a three year period, spring-born English cross-bred steer calves (72 head each year) were randomly assigned to one of three winter-stocker growth rate treatments in early December. Animals were bunk-fed timothy hay-based diets during the stocker period with either supplemental soybean meal or soybean meal and soybean hulls to achieve protein and energy balance. A commercial mineral mix containing a trace mineral and vitamin package was fed throughout the experimental periods. Winter diets were formulated to achieve average daily gains (ADG) of 0.5(L), 1.0 (M) or 1.5 (H) lb per day. Upon completion of the winter stocker period, animals within winter treatment were randomly assigned to either pasture or feedlot/concentrate finishing treatments. Pasture cattle were finished in Union, West Virginia on naturalized pasture (bluegrass, orchardgrass, fescue, and white clover mix), hay meadow re-growth (orchardgrass and alfalfa/grass mixture) and triticale/Italian ryegrass. Dry matter basis (DMB) mean crude

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protein (CP) content of pasture was 18.0% and invitro dry matter disappearance (IVDMD) was 81.3%. Concentrate cattle were finished at Steeles Tavern, Virginia (76.0% shell corn, 18.0% corn silage, and 5.6% soybean meal; DMB). The finishing period began in Mid-April and concluded around the end of September. Pasture and concentrate cattle were fed to an equal time endpoint and then harvested to alleviate confounding due to animal age or environment. Cattle were approximately 18 months of age when harvested. Carcass data were collected at time of slaughter and the left 107 rib (with chine) from each carcass was purchased for later chemical and sensory evaluation. Pasture cattle were de-wormed and received fly control treatment using commercial products throughout the grazing season.

Results and Discussion

Winter Stocker Performance: Winter initial body weight was 597, 597 and 589 lb for L, M and H treatments respectively. Stocker treatment diets resulted in ADG of 0.64, 1.15 and 1.74 lb and final weights of 683, 750 and 816 lb for the L, M and H treatments, respectively. Ending loin muscle area (ultrasound measured) differed as a result of winter treatment being: 7.4, 8.3 and 9.1 sq. in. for L, M and H respectively. Animals on the L treatment showed no growth in ribeye area during the stocker period. Although not statistically different ($P = 0.0979$), there was a trend for H to have greater intramuscular fat than L and M. Our goal of having three distinct populations upon completion of the stocker period was achieved.

Finishing Period Performance and Carcass Quality: Discussion in this section will be limited to cattle finished on pasture. No winter treatment by finishing treatment statistical interactions were observed for data presented, therefore differences (or lack there of) due to winter stocker treatment for pasture cattle were similar in those finished on concentrate.

Mean start weights for pasture finished cattle were 691, 753 and 821 for L, M and H winter stocker treatments respectively. Winter stocker treatment resulted in the expression of compensatory gain during pasture finishing in L and M cattle relative to H. Low winter gain resulted in finish ADG of 2.11 lb, M was 1.85 while H had 1.68. However, cattle gaining the least during winter were not able to catch up to H in terms of final body weight and M cattle did not differ statistically from L or H. Final body weights were 1019, 1038 and 1080 for L, M and H respectively. These results indicate L treatment sacrificed saleable live animal when harvested at the same time endpoint. If we assume L could gain 1.65 from harvest point forward (if left on pasture), they would need an additional 37 days to attain the same end weight of H. Individual producers will need to decide economic feasibility of higher or lower winter rate of gain based on associated costs, marketing strategies and personal goals. Regardless of the economic impact, these data clearly indicate compensatory gain could not make up for lower gain during the winter when animals were harvested at a equal time endpoint. These same trends occurred in feedlot finished cattle indicating diet energy density was not an issue.

Carcass fat thickness and loin muscle area were not influenced by winter stocker treatment with overall means being 0.19 in. and 10.3 sq. in. respectively. There was a trend for yield grade (P=0.12) and kidney pelvic and heart fat (P=0.07) to be influenced by winter rate of gain with values being: 1.5, 1.7 and 1.7, and 1.4, 1.6 and 1.7% respectively.

Dressing percent, carcass weight (CW) and quality grade (QG) were influenced by winter rate of gain. Dressing percent was 53, 54 and 55% for L, M and H respectively. These data agree with previous research concerning pasture-finished beef. Mean carcass weight of H was 49 lb heavier than L and 31 lb more than M (actual CW: L = 523 lb, M = 541 lb, H = 572 lb). If we assume a 60% yield for boneless retail product from the carcass and an overall value of $5.00 per lb, income would increase by $147.00 for H versus L and $93.00 versus M. Clearly, winter performance can have a major impact on income when animals are finished to a same time endpoint.

Carcass QG is reported on the following scale: 4 = Choice -, 3 = Select +, 2 = Select –, and 1 = Standard +. The overall mean QG was 2.1 with L, M and H being 1.9, 2.1 and 2.5 respectively. High winter rate of gain was greater than L but M did not differ from L or H. Select QG was achieved in M and H treatments and lower gain in winter reduced intramuscular fat. Our data indicate that in order to have the highest possible QG, gain during the stocker period should be maximized. Economical feasibility of higher rates of stocker gain will depend on input costs and if QG impacts consumer acceptability.

Implications

Animal performance during the winter stocker period clearly impacts finishing performance, carcass quality and beef production. Although compensatory gain was expressed during finishing, Low rates of gain cattle were never able to catch up to the high rate (projected 1.5 lb ADG) in terms of live body or carcass weight, when finished to an equal time endpoint. We found that carcass quality grade was sacrificed in the low rate of gain treatment. Given that most pasture finished beef is not sold as a commodity product, this is not necessarily a negative unless it compromises product acceptance by the consumer. Cattle which perform at lower rates during winter may be able to improve carcass quantity and quality if finished for a longer period of time and that strategy could be useful to expand the harvest window and improve the distribution of product in time. Our recommendation is for a minimum ADG of 1.0 lb during the winter stocker period to maximize beef production and carcass quality during finishing.

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Using Winter Annuals to Extend the Finishing Season

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Climate constrains the duration of the pasture finishing season for beef on perennial pastures all across the country. Winter annual forages provide the most cost effective way of extending the finishing window in almost every geographical location in the US. Winter annuals can extend high quality grazing much later into the fall and winter as well as providing quality forage earlier in the spring. From high mountain valleys in Idaho to the coastal plains of Texas, winter annuals are a valuable part of the forage chain.

How and when you use winter annuals depends on your location and what other pasture resources you have available. Winter annuals play a far greater role in finishing programs in the South than they do in any other region. Hot summer temperatures and the heat stress it places on cattle limit the finishing window to cooler seasons all across the South. Winter is the season of opportunity in the South and winter annual forages provide the foundation for most of the winter beef production.

In the Intermountain West, winter annuals can add a month or two to the Autumn finishing window but won't provide quality forage through the winter as they do in the South. The same plant species might be used in the two locations, but they behave quite differently and serve a different purpose. It's critical to know what species will best fill the need in your location and the local management required to capitalize on the opportunity. Annual ryegrass might not be planted in Texas until October but the same variety needs to be planted by mid-July in Idaho or Montana for grazing in October.

Small grains and annual ryegrass are the easiest of the winter annuals to establish and manage for grazing. Most of the species can be planted either as monocultures or mixtures. For the Midwest, I particularly like a mixture of oats and annual ryegrass. The oats come on rapidly in the fall and provide high quality grazing until frost. Annual ryegrass comes a little later and stays green as the oats are frosting. While oats did not survive the winter, the annual ryegrass did and would be the first pastures greening in the spring to provide early season grazing. Numerous guidesheets are available from Cooperative Extension and seed companies to provide varietal recommendations and seeding rates and times for your area. Because winter annuals are used across such a wide range of environments, it is not possible to cover all the nuances of local management in this format.

Winter annual legumes are the second class of most commonly used winter annual forages. In general these species don't provide much forage on the front side of winter but provide early high quality forage in the spring, plus, they are capable of fixing significant quantities of nitrogen that will become available for summer pastures. Arrowleaf, crimson, berseem, and ball clover are common winter clover species. Ball clover has the greatest fall production and can help out on the front side of winter more than any other legume. Many of the winter annual legumes do not survive severe winter so their use is limited to the South and lower Midwest. Hairy and common vetch are two other winter annual legumes that can be used from the Deep South into the Midwest and Northeast.

Brassica species such as turnips and kale can also be used for pasture finishing, although there is a risk of vegetative flavoring in the meat if they compose too much of the diet. Mixing the brassica with a small grain or ryegrass often gives better results than using them alone. Research studies in Missouri have found kale to yield 3-5 tons of forage dry matter in the late fall. Brassicas can quickly lose quality with several killing frosts so they should be used in late fall or early winter, depending on location. Because they establish quickly and can usually be grazed within 50-70 days of seeding, they are a good transition crop between perennial pastures and winter annual grasses.

All of the winter annual species perform best with rotational grazing. Even turnips can regrow if only moderately grazed in the first cycle. In the deeper South where winter annuals may continue to grow most of the winter, set stocking at a moderate stocking rate has yielded very good animal performance and kept the pastures vigorous. If forage supply becomes limiting, intake will drop rapidly and finishing gains may no longer be achieved. If you try set stocking winter annuals, carefully monitor forage residual and quality throughout the winter.

Most producers using winter annuals for finishing pasture use very intensive strip grazing to try to keep intake high while allowing the forage an opportunity to regrow following grazing. As with almost all annual crops, once seedhead or flower development begins forage quality drops below finishing requirements. Legumes do maintain somewhat better forage quality with maturity than do either the grasses or brassicas. Plan to have the crop fully utilized before the onset of maturity to maximize gains.

Using a series of several annual crops can spread out the maturity window and provide more days of quality grazing than any one species is likely to provide. Individual varieties within a species may have enough variation in maturity characteristics to justify seeding more than just one variety. There is plenty of maturity difference across species to extend the window of finishing quality pasture. An extended supply of finishing quality pasture is the product of extensive planning and intensive management. It will not happen by accident.

Economics and Feed Values of Various Harvest and Storage Protocols

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The economics of various harvest and storage systems and determining which will be the most profitable are dependent upon the existing equipment and the harvest system currently in place. No one system is a best fit for all farms, even within a given geographic or climatic region. What works very well for one farm may not work at all on another farm. What will be presented here are concepts and principles to be considered rather than specific recommendations.

In general, grazing leads to lower costs of production and higher quality feed consumed. The quality of the feed required varies with the age of the animal, with lower quality feed required in the cow-calf phase than in the finishing phase of production. There is much more information available on how to feed the cow-calf enterprise or the stocker enterprise than there is on how to feed during the finishing phase. Being successful in the grass finishing phase is much more of a challenge than being successful in the cow-calf and stocker (backgrounding) phases.

Effects of various forage species and different harvest and storage methods on performance and carcass characteristics in an integrated system are not well understood. Animal performance on forage diets is typically limited by energy intake. Scientists at Virginia Tech investigated various forage systems for beef production from conception to slaughter. Six year-round, all-forage, 3-paddock systems for beef cow-calf production were used to produce five calf crops during a 6-year period (Allen at al., 1992a). Forages grazed by cows during spring, summer and early fall consisted of one paddock of either 1) tall fescue (*Festuca arundinacea* Schreb.)-ladino clover (*Trifolium repens* L.) or 2) Kentucky bluegrass (*Poa pratensis* L.)-white clover (*Trifolium repens* L.). Each of these two forage mixtures were combined with two paddocks of either 1) tall fescue-red clover (*Trifolium pratense* L), 2) orchardgrass (*Dactylis glomerata* L)-red clover or 3) orchardgrass-alfalfa (*Medicago sativa* L.), which were used for hay, creep grazing by calves, and stockpiling for grazing by cows in late fall and winter. Tall fescue was <5% infected with *Neotyphodium coenophialum* endophyte.

Daily gains and weaning weights of calves differed little among forage systems (Figure 1). Digestibility of dry matter (DM), crude protein (CP) and acid detergent fiber (ADF) were greater ($P < .05$) for orchardgrass-legume hays than for the tall fescue-red clover hay but all systems produced satisfactory cattle performance. Blaser et al. (1986) reported that when 4-month-old calves had access to creep-grazed forage, increased nutrition for cows did not improve calf performance. Allen et al. (1992a) found in the above study that allowing calves access to high-quality, plentiful forage by creep grazing

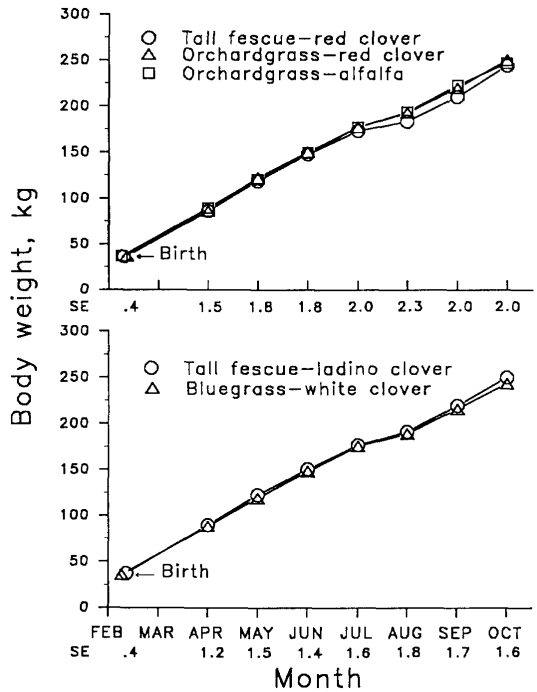

Figure 1. Influence of six all-forage systems on calf performance. Source: Allen et al., 1992a

resulted in similar daily gains by calves regardless of the forage species used. Cows grazing stockpiled tall fescue-red clover gained more ($P < .05$) weight from November to January than cows grazing orchardgrass stockpiled with either red clover or alfalfa. Hobbs et al. (1965) found greater daily gains by steers grazing tall fescue in winter than by those grazing orchardgrass, regardless of clover content or N fertilizer. Baker et al. (1965) reported greater gains by cattle grazing tall fescue-dominant pastures than by those grazing orchardgrass during November and December when the pastures were left ungrazed from mid-August to November.

Allen et al. (1992a) reported that while all systems tested produced high calf weaning weights, regardless of forage species grazed, orchardgrass and red clover did not persist and orchardgrass-alfalfa increased the need for mechanical harvesting and hay feeding. Bluegrass-white clover provided less forage than tall fescue-ladino clover. Using tall fescue-ladino clover for summer grazing by cows, combined with tall fescue-red clover for creep grazing, hay and stockpiling for winter forage, required one hay harvest each year to produce approximately 1430 lb of hay. They concluded that tall fescue-red clover and tall fescue-ladino clover provided an easily managed system for cow-calf production that supplied adequate nutrition for cows and calves, required minimum mechanical and labor requirement, and resulted in a 550 lb weaning weight for Angus calves.

In the stocker phase, fall-weaned Angus calves grazed stockpiled 1) tall fescue, 2) tall fescue-red clover, or 3) tall fescue-alfalfa or were barn-fed 4) tall fescue hay, 5) orchardgrass-alfalfa hay, or 6) tall fescue silage from late October to early April during each of 5 years (Allen et al., 1992b). Percentage of endophyte infection in N-fertilized tall fescue averaged 42% (28 to 55%) among four replicates whereas percentage of infection in tall fescue in fescue-red clover replicates averaged 27% (0 to 48%) and tall fescue in the tall fescue-alfalfa system contained no endophyte infection. No correlation ($P < .20$) was found between animal performance and percentage of endophyte infection in N-fertilized, stockpiled tall fescue and tall fescue grown with either red clover or alfalfa.

Table 1. Influence of six all-forage growing systems on performance of stocker cattle.

	Stockpiled forage			Hay		Silage	
Item	Fescue-N	Fescue-Red clover	Fescue-Alfalfa	Fescue-N	Orchardgr-Alfalfa	Fescue-N	SE
	lb						
Daily gain	.75	.73	1.10	.40	1.10	.15	.04
Total gain	125	123	183	73	189	29	7

Each value represents a mean of 60 cattle except for stockpiled fescue-N for which each value represents a mean of 120 cattle.

Stockpiled fescue-alfalfa differs from stockpiled fescue-red clover and stockpiled fescue-N, fescue hay differs from fescue silage, and orchardgrass-alfalfa hay differs from fescue hay and fescue silage (all P < .01).

Source: Allen et al., 1992b.

Daily gains by calves grazing stockpiled tall fescue-alfalfa were greater (P < .01) than by calves grazing stockpiled tall fescue-red clover or N-fertilized, stockpiled tall fescue (1.10, .73 and .75 lb/day, respectively, Table 1), but tall fescue-alfalfa calves required more days (P < .01) of supplemental hay feeding (105, 60 and 36, respectively). Allen et al. (1992b) stated that other unpublished Virginia Tech research with endophyte-free tall fescue demonstrated improved daily gains by steers grazing tall fescue stockpiled with alfalfa compared with red clover (2.2 vs. 1.8 lb/day, respectively; P < .01). Calves fed tall fescue hay in the barn gained more (P < .01) than those fed tall fescue silage. Feeding orchardgrass-alfalfa hay resulted in greater gain (P < .01) than feeding tall fescue hay or tall fescue silage (1.10 vs. .40 and .15 lb/day, respectively). Differences in gains paralleled differences in dry matter intake by cattle fed either hay or silage. Grazing stockpiled tall fescue-alfalfa gave animal performance similar to that resulting from feeding orchardgrass-alfalfa hay (Figure 2) and required about half as much hay.

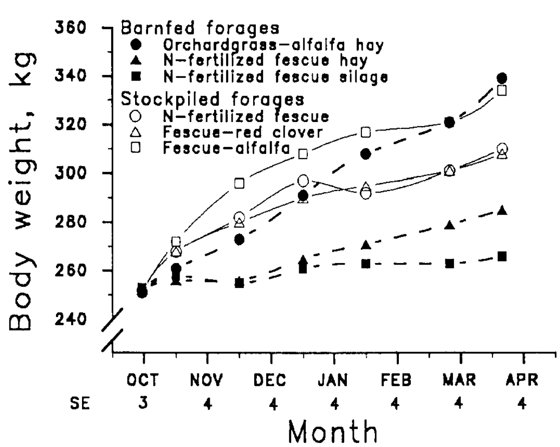

Figure 2. Influence of six all-forage systems on body weight gain by stocker cattle. Source: Allen et al., 1992b.

Allen et al.(1992b) concluded that several forage systems can be successfully used to winter stocker cattle, but animal performance and requirements for stored feed differ among systems. Tall fescue stockpiled with alfalfa instead of by applying N fertilizer reduced yield, but improved gain by stocker cattle, compared with N-fertilized tall fescue.

Cattle grazing stockpiled tall fescue-legume systems required more (P < .01) forage fed as hay and more days of hay

Table 2. Hay and silage fed and number of days harvested forage was fed to stocker cattle on six all-forage systems..

	Stockpiled forage			Hay		Silage	
Item	Fescue-N	Fescue-Red clover	Fescue-Alfalfa	Fescue-N	Orchardgr-Alfalfa	Fescue-N	SE
Forage fed lb/head	475	730	1547	1938	2693	1184	20
Days fed	33	49	100	162	182	142	1

Stockpiled forages differ from the mean of hay and silage systems, stockpiled fescue-N differs from means of fescue-legumes, stockpiled fescue-red clover differs from stockpiled fescue–alfalfa, fescue hay differs from fescue silage, and orchardgrass-alfalfa hay differs from the mean of fescue hay and fescue silage (all P < .01).

Source: Allen et al., 1992b.

feeding than calves grazing N-fertilized, stockpiled tall fescue (Table 2 and Figure 3). Stockpiling tall fescue with red clover required approximately 50% more days of hay feeding, whereas stockpiling tall fescue with alfalfa required approximately three times the number of days of hay feeding compared with N-fertilized, stockpiled tall fescue. In barn-fed systems, stocker cattle consumed more (P < .01) orchardgrass-alfalfa hay than did those fed tall fescue hay and tall fescue silage (Table 2 and Figure 3). Cattle consumed more (P <.01) tall fescue hay than tall fescue silage dry matter.

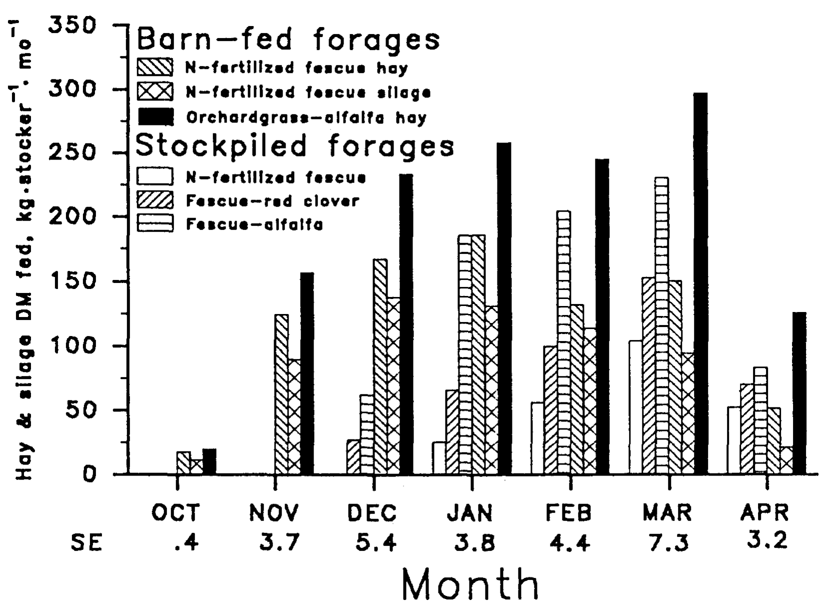

Figure 3. Total stored forage DM consumed by month on six all-forage stocker systems for cattle averaged over 5 years. Source: Allen et al., 1992b.

Intake by steers in digestion trials differed (P < .01) among forages. Dry matter intake was 6.6, 7.9, 9.0, 9.9 and 6.4 lb/day (dry basis) for N-fertilized tall fescue hay, tall fescue-red clover hay, tall fescue-alfalfa hay, orchardgrass-alfalfa hay and N-fertilized tall fescue silage, respectively. Percentage of CP was 9.5, 9.1, 12.7, 12.6 and 9.7 (DM basis), and percentage ADF was 42, 42, 42, 40 and 44 (DM basis) for the respective forages. Digestibility of DM did not differ among all harvested feeds and averaged 60%. The researchers indicated that selective grazing of high-quality forage by grazing stockers may have increased the quality of the diet compared with stockers fed hay or silage in the barn.

Greater gains by calves fed N-fertilized tall fescue hay than by those fed fescue silage cannot be attributed to differences in percentages of CP and ADF or digestibility of DM, CP or ADF. Poor performance by cattle fed the silage may have been related to infection with the endophyte in tall fescue, even though the percentage of infection (average 42%) should have been similar among forage stockpiled for winter grazing and forage harvested in spring as hay and silage, because the same areas were used to produce all three feeds. Buttrey (1989) found that spring-cut tall fescue hay and silage and stockpiled, ensiled, fall-cut tall fescue contained 2.7, 27.2 and 18.2 ppm of ergopeptine alkaloid, respectively, suggesting that method of preservation and time of harvest influence (P < .01) concentration of ergopeptine alkaloids. Hence, differences between hay and silage in alkaloid concentrations could have influenced animal performance in this study even though they were harvested from the same area.

Animal performance during the stocker phase has primary influence on performance during the finishing phase (Allen et al., 1996). Following the stocker winter feeding systems outlined previously, the calves either grazed 1) N-fertilized tall fescue alone, 2) Kentucky bluegrass-white clover sequenced grazed with tall fescue-red clover or 3) bluegrass-white clover sequence grazed with alfalfa-orchardgrass. In the finishing phase of the system, heifers were supplemented with grain at 1% of body weight (BW) from April until slaughter in July. One-half of the steers were supplemented with grain at 1% of BW from July until slaughter in October. Remaining steers were fed no grain but were finished on corn silage supplemented with 2 lb of soybean meal per steer daily from October until slaughter in late January. Including alfalfa-orchardgrass in systems during the finishing phase resulted in higher daily and total gains for all cattle during grazing period, and carcasses had more marbling and higher USDA quality grades at slaughter compared with carcasses of cattle 0n systems using tall fescue-red clover.

Allen et al. (1996) reported that performance and carcass characteristics were influenced as much or more by forage consumed during the previous wintering phase as by forage fed during the finishing phase. Wintering cattle on stockpiled tall fescue-alfalfa or alfalfa-orchardgrass hay generally resulted in higher BW at slaughter and more desirable carcass characteristics than systems using tall fescue alone or in combination with red clover. This was particularly notable in steers that grazed without grain until October and were finished on corn silage plus supplement. Heifers that grazed alfalfa-orchardgrass had greater (P < .05) gains, final BW, and carcass weights than heifers that grazed tall fescue-red clover. Carcasses of those heifers had higher (P < .05) quality and yield

Table 3. Performance and carcass characteristics of steers that grazed two forage systems from April to October followed by finishing on corn silage.

	Sequence grazed with bluegrass-white clover		
Item	Fescue-red clover (n = 45)	Orchardgrass-alfalfa (n = 43)	SEM
Grazing period (Apr to Oct)			
Initial weight (Apr), lb	708	708	11.4
Daily gain, lb*	1.23	1.47	.04
Total gain, lb*	235	282	7.5
Oct weight, lb*	942	994	10.6
Feedlot period (Oct to Jan)			
Daily gain, lb	3.65	3.50	.07
Total gain, lb	301	288	6.6
Final weight (Jan), lb*	1243	1283	13.2
Carcass weight, lb*	686	708	8.2
Quality grade*[a]	10.2	10.9	.22
Yield grade	2.3	2.3	.09
Marbling*[b]	3.3	3.6	.10

* Effect of finishing system ($P < .05$).
[a] 9 = low select, 10 = average select
[b] 2 = traces, 3 = slight
Source: Allen et al., 1996.

grades, more marbling, back fat and percentage kidney-pelvic-heart fat, and a higher dressing percentage than heifers that grazed tall fescue-red clover. Maturity, rib eye area and fat color were not influenced by finishing forage system.

Steers slaughtered in January that sequence grazed alfalfa-orchardgrass had greater ($P < .05$) daily and total gains during the grazing season and greater ($P < .05$) BW in October when they entered the feedlot than those that grazed tall fescue-red clover (Table 3). Those steers also had greater ($P < .05$) final BW at the end of the corn silage feeding period than the steers that had grazed tall fescue-red clover. Carcass weights, quality grades, marbling score, and the percentage of kidney-pelvic-heart fat were all greater ($P < .05$) in steers that had grazed alfalfa-orchardgrass the previous summer than in steers that had grazed tall fescue-red clover. Fat color was not affected by forage system.

The all-fescue system resulted in slower ($P < .05$) daily and total gains of steers than sequence grazed systems during the grazing season (Table 4). No differences in gain were reported during the feedlot finishing period. At slaughter, carcass weight, quality grade, marbling, rib eye area, dressing percentage, and fat color were not affected by summer forage treatment.

When grazing began in April, steers from the stockpiled tall fescue-alfalfa weighed more ($P < .05$) than steers wintered on stockpiled tall fescue-red clover. Likewise, steers wintered on alfalfa-orchardgrass hay weighed more ($P < .05$) than those fed tall fescue

Table 4. Performance and carcass characteristics of steers that grazed stockpiled tall fescue during winter and three forage systems from April to October followed by finishing on corn silage.

Item	N-fertilized fescue (n = 15)	Fescue-red clover (n = 10)	Orchardgrass-alfalfa (n = 7)	SEM
	Finishing system			
Grazing period (Apr to Oct)				
Initial weight (Apr), lb	708	717	698	17.8
Daily gain, lb*	1.21	1.34	1.50	.09
Total gain, lb*	231	257	286	17.8
Oct weight, lb	926	970	972	25.1
Feedlot period (Oct to Jan)				
Daily gain, lb	3.74	3.48	3.52	.18
Total gain, lb	310	288	290	15.06
Final weight (Jan), lb	1236	1258	1265	31.02
Carcass weight, lb	673	697	700	18.9
Quality grade[a]	10.8	9.8	11.1	.42
Yield grade	2.0	2.0	2.2	.14
Marbling[b]	3.5	3.1	3.5	.18

* Fescue-N differs from the mean of sequenced grazed systems (P < .05).
[a] 9 = low select, 10 = average select, 11 = high select
[b] 2 = traces, 3 = slight
Source: Allen et al., 1996.

hay or silage. Steers fed fescue hay and silage had faster (P < .05) daily gains than steers that were wintered on alfalfa-orchardgrass hay, however, those cattle were lighter at slaughter in spite of their faster daily gains.

The improved performance of all cattle that grazed alfalfa-orchardgrass was reflected in higher (P < .05) quality grades. Quality grades of heifers slaughtered in July and steers slaughtered in October averaged within the Select grade whereas quality grades averaged Standard for steers and heifers that had grazed tall fescue-red clover.

Allen et al. (1996) stated that the value of alfalfa-orchardgrass may have been due to more forage available for grazing, although measurements of forage mass did not always indicate a consistent difference. Alfalfa may have been more productive during periods of low soil moisture as well as the researchers reported a higher percentage of legume in the alfalfa-orchardgrass mixture than in the tall fescue-red clover.

Stocker systems that contained alfalfa seemed to have a beneficial influence on cattle during the finishing phase. The heavier BW of both steers and heifers that were fed alfalfa-orchardgrass hay during the stocker phase, compared with cattle wintered on fescue hay or silage, were still observed in heifers at slaughter in July and in steers in October, whether or not they were fed grain on pasture. Wintering cattle on fescue hay or silage not only resulted in lighter cattle at the end of the stocker phase, but these cattle never overcame the effects of their stocker forage. Allen et al.(1996) stated that the carryover effects of the cattle fed the fescue hay or silage during the wintering phase seemed due more to a lack of dry matter intake than to endophyte per se, because cattle wintered on the same tall fescue as stockpiled forage did not exhibit this long-term influence.

Type of forage fed during the stocker phase of beef cattle production influences performance and carcass characteristics of finishing cattle as much as or more than forages fed during finishing.. Feeding tall fescue (average 42% infection with endophyte) as hay or silage during the stocker phase resulted in slower body weight gains that were not overcome by compensatory gains during finishing, even when cattle were finished on corn silage plus a protein supplement; but grazing the tall fescue as stockpiled forage had no carryover effects. Including alfalfa either as grazed forage or hay during the stocker phase improved gains and resulted in improved performance during the finishing phase.

Annual forages can be high quality and support good animal performance but require more labor, equipment and other inputs such as seed. Warm-season perennials can fill the mid- and late summer slump in cool-season grass production. Allen et al. (2000) compared four forage systems for production of stocker steers in the upper South. Autumn-weaned Angus crossbred steers were allocated to four forage systems that began in mid-November and continued through mid-October for 4 years as follows: System 1) tall fescue and Kentucky bluegrass-white clover; System 2), tall fescue, caucasian bluestem (*Bothriochloa caucasica* [Trin.] C. E. Hubbard), and tall fescue-red clover; System 3) orchardgrass-alfalfa and bluegrass-white clover; and System 4) rye (*Secale cereale* L.), soybean (*Glycine max*)-German foxtail millet (*Setaria italica*), and bluegrass-white clover. All steers were supplemented with hay or silage cut from their respective systems when forage for grazing was limited.

System 2 which used stockpiled tall fescue for winter grazing and caucasian bluestem for summer forage plus tall fescue-red clover for hay and grazing in a three-paddock system resulted in greater ($P < .01$) gain/per acre and per steer, more grazing days, and reduced stored forage requirements and produced more surplus feed than the other systems tested (Table 5 and Figure 4). Gains per acre for Systems 1 through 4 were 405, 495, 422 and 435 lb, respectively. Harvested forage from Systems 1, 2 and 3 met needs for stored forages but System 4 required additional hay from outside of the system. Stored forage was fed for 61, 38, 112 and 104 days for Systems 1 through 4, respectively.

Steers in System 2 gained approximately 67 lb more gain/acre compared with Systems 3 and 4 ($P < .01$) and an increase of 89 lb gain/acre compared with System 1. Steers in System 2 had higher ($P < .01$) final weights, average and total gains, and gain/acre than steers in each of the other three systems. Including annual forages (System 4) did not increase performance over the system that used orchardgrass-alfalfa (System 3) for hay and grazing.

Table 5. Influence of four forage systems on performance of stocker steers.

Item	Tall fescue/ bluegrass- white clover (System 1)	Tall fescue/ caucasian bluestem/ fescue-red clover (System 2)	Alfalfa- orchardgrass/ bluegrass white clover (System 3)	Rye/ soybean- millet/ bluegrass- white clover (System 4)	SE
	lb				
Initial weight	372	370	372	372	2
Daily gain[ab]	1.03	1.28	1.08	1.12	.04
Total gain[ab]	337	414	352	365	13
Gain/acre[ab]	405	495	422	435	16

Each value represents a mean of 8 steers.
[a] System 1 differs from the mean of Systems 2, 3 and 4 (P < .01).
[b] System 2 differs from the mean of Systems 3 and 4 (P < .01).
Source: Allen et al., 2000

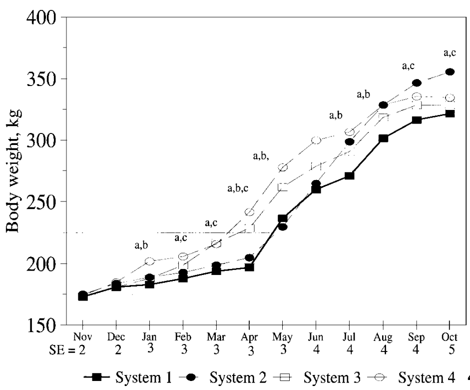

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Figure 4. Performance of stocker steers from November to October on four forage systems in Virginia (n = 8 for each mean; [a] indicates a difference between System 1 and the mean of the other three systems; [b] indicates a difference between System 3 and System 4; and [c] indicates a difference between System 2 and the mean of Systems 3 and 4). Source: Allen et al., 2000.

Allen et al. (2000) reported that steers in System 2 demonstrated an increased (P < .01) rate of gain, compared with steers in System 1, after they were moved to caucasian bluestem pastures in mid-June (Figure 4). This advantage was maintained throughout the remainder of the grazing season. Steers that grazed alfalfa-orchardgrass and were alfalfa-orchardgrass hay (System 3) had higher (P < .01) daily gains then those on tall fescue (Systems 1 and 2) beginning winter, and this advantage continued through spring. Daily gains by those steers slowed as the summer progressed, when grazing was largely confined to bluegrass-white clover, resulting in no difference in final weights between steers on System 3 and 1 (Figure 4). Grazing rye combined with soybean-millet silage (System 4) resulted in the highest rate of gain during winter and this rate continued through spring. As with System 3, rate of gain slowed when steers grazed only bluegrass-white clover during summer.

Allen et al. (2000) concluded that the warm-season perennial grass for mid-summer forage and tall fescue-red clover accumulated for late summer grazing in System 2 provided the best match of forage quantity to the increasing animal feed demand as the steers grew. They stated that grazing systems are site-specific and results will be altered as changes are made in climate, soils, adaptation of forage species, kinds and classes of livestock, and other influencing factors. Shifting the systems evaluated in Virginia geographically toward greater dependence on either cool- or warm-season forages would alter the outcomes and require substitution of alternative forages.

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Summary

The cow-calf phase of production offers more alternatives for forage species selection and possibly a greater opportunity to extend the grazing season than the stocker and finishing phases of production. Tall fescue in combination with legumes can be used more successfully in the cow-calf phase than in the other phases. Animal performance during the stocker phase has primary influence on performance during the finishing phase. Wintering cattle on tall fescue hay or silage not only resulted in lighter cattle at the end of the stocker phase but those cattle never overcame the effects of their stocker forage, however grazing tall fescue as stockpiled forage had no carryover effects. Including alfalfa either as grazed forage or hay during the stocker phase improved gains and resulted in improved performance during the finishing phase.

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Animal Genetics for Effective Use of Pastures

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Basic Nutrition Concepts

Feed intake in cattle will be used for one of three purposes:

1. Maintenance
2. Weight gain
3. Lactation

For the grass-fed steer, maintenance requirements will be determined by the amount of weight the animal must maintain, and variation will be due to environmental issues such as heat or cold, health, and travel. The basic calculation for megacalories for animal maintenance in a thermal-neutral environment is usually .077 X animal weight $^{0.75}$. This value represents the amount of energy required to keep the animal alive at a resting state. It would be slightly higher in animals with a larger gut weight relative to total weight such as dairy breeds. For a 700-lb steer, the requirement would be 40 Mcal of energy or about 55 lbs of orchardgrass. The first limiting nutrient for grazing yearling steers will be energy, and protein needs are fairly low.

Weight gain is defined as additional bone, muscle or other tissue. It is not a part of water or feed that is in the digesta. The weight gains shown in Table 1 for both grass and alfalfa/grass pastures are those expected based on the weight of the cattle and the energy content of the grass at maximum intake of the forage.

Table 1. Energy value and expected daily weight gains of steers grazing orchardgrass and alfalfa/grass pastures

<u>Grass</u>
Alfalfa/grass

	May	June	July	August	September	October	November	December
ADF %	29.3	35.9	35.9	35.6	34.5	33.1	34.4	37.5
	32.4	34.8	37.2	35.3	36.3	33.2	30.1	
NEm	0.71289	0.62907	0.62907	0.63288	0.64685	0.66463	0.64812	0.60875
	.67623	.64564	.61516	.63928	.62659	.66596	.70533	
TDN	68.91	61.38	61.38	61.72	62.98	64.57	63.09	59.56
	65.59	62.86	60.12	62.29	61.15	64.68	68.21	
ADG	2.05	1.45	1.45	1.6	1.8	2.1	2	1.7
	1.95	1.49	1.42	1.61	1.74	2.1	2.2	

Adapted from Comerford et al. (2004)

These data show that under most conditions, grazing yearling steers will not be able to gain more than 2.0 lbs. per day for extended periods of time. Exceptions would be cattle that have access to significantly higher-energy feeds or short-duration weight compensation. Actual weight gain for cattle on the same pastures confirmed this (Steinberg, et al, 2006). Mature cows will gain weight for an extended period on pasture from additional body fat accumulation. Secondly, evaluation of forages that included fescue, rape, oats, orchardgrass, alfalfa/grass mixtures, sudangrass, and annual rye in central Pennsylvania over 3 years (Comerford et al., 2004) indicated there was little variation in the energy value of these forages for any period of the growing season when kept in a vegetative state. Protein content of all forages was more variable, but never went below animal requirements for the three years of evaluation. This may not be the case for some native grasses.

Affects of Animal Genetics

The market for the beef produced, either as a live steer or as beef products, should determine the animal genetics employed on the farm. For example, genetic selection will be an important factor in maintaining final carcass weights in an acceptable range. Similarly, production traits-growth, fat thickness, marbling and grade, muscling-can also be altered from animal genetics. Consider the data shown in Table 2. In this case, animal growth would be the most important factor to consider for yearling steers harvested as grass-fed beef at 16-18 months of age since fat, marbling, frame size, or days on grass did not tend to vary with consumer acceptability of the meat (Steinberg et al, 2006).

Table 2. Analysis of covariance among animal, production, carcass, and consumer panel scores for grass-fed steaks

Probability of significant covariance[1]

Dependent trait	Covariants					
	Sex[2]	frame	YG	final wt.	grazing days[3]	marbling	carwt.
Juiciness[5]	.15	.07	.01			.21	
Flavor	.60	.30		.62			.98
Tenderness	.20	.23		.78	.28		.14
Texture	.44	.36	.24	.53	.45		
Overall	.12	.43		.23	.73		

[1] Level of significance =P<.05.
[2] Sex=fixed effect.
[3] Grazing days were 124 d, 138 d, 145 d, 159 d, 173 d, or 187 d.
[4]400=slight^{0}; 500=small^{0}.

Table 3. **Mean values of animal, carcass, and consumer panel traits for grass-fed steers and heifers**

Trait	Mean Value	s.d.	Minimum value	Maximum value
Age at harvest (d)	532.9	5.7	519.0	542.0
Winter gain (lbs)	209.9	45.1	72.6	299.0
Weaning wt. (lbs)	662.4	92.0	440.0	878.0
Initial wt. (lbs.)	872.5	92.4	641.1	1177.0
Frame size	5.0	0.7	3.6	6.7
Grazing wt. gain (lbs/d)	1.52	0.3	.30	2.08
Final wt. (lbs)	1110.0	75.2	985.8	1260.0
Hot carcass wt. (lbs)	616.4	22.2	533.0	696.1
Ribeye area (sq. in.)	10.7	.7	9.1	12.0
Marbling score[1]	448.3	36.1	400.0	530.0
Fat thickness (in.)	.24	.07	.10	.40
Yield grade	2.5	0.3	1.9	3.3
Juiciness[2]	3.10	0.44	2.14	3.90
Tenderness	2.54	0.72	1.57	4.00
Flavor intensity	5.17	0.94	3.43	6.71
Texture	4.37	1.36	2.43	7.00
Overall acceptability	4.67	1.20	2.29	7.00

[1] 400=slight^0; 500=small^0.
[2] Overall liking, flavor, and texture panelists used a 9 point hedonic scale with 9 = like extremely and 1 = dislike extremely. Tenderness and juiciness was scored on a 7 point "just about right" scale with 7=extremely tender or extremely juicy and 1=much too tough or much too dry with 4=just about right.

The data shown in Table 3 is from the same group of cattle as those in Table 2. What is apparent is that there is considerable variation in production traits that do not seem to affect consumer evaluations of the meat for cattle harvested at a similar age. This result provides an excellent opportunity to select cattle for the most economical traits without jeopardizing consumer value. Since grass-fed cattle are seldom graded (and there is little or no data to distinguish product value based on grade of grass-fed beef), the most important factors to consider would be animal age, animal weight, and carcass leanness.

Influence of Selected Production Traits on Pasture Management

The goal of pasture management would be to most effectively match the production traits of highest value with forage quality and availability to have those traits fully expressed. From the example above, animal growth appears to be a very important factor. To maximize growth, the energy value of the forage and the ability to graze maximum amounts will be key issues. This will translate into using forages that are maintained at high levels of quality by clipping, effective grazing, rest period, and effective rotations. Forage variety may have little effect on this trait in temperate regions except there is some indication alfalfa intake may be compromised compared to grasses. Forage energy will be compromised by maturity levels. In general, those traits associated with fat production-fat thickness and marbling-requires the highest level of consistent, high-energy feed intake. There must be sufficient energy intake to partition some of the energy into fat production in addition to growth and maintenance. Likewise, optimum growth can be achieved at less energy density of the diet, but intake must be maintained. The following table outlines some of the pasture needs for specific production traits.

Pasture Consistency

In addition to maintaining energy value in the pasture, consistent dry matter availability will be a key issue. Recent work with ultrasound marbling measurements illustrates how consistent feed intake at a specific level of energy density will affect marbling deposition, and this would be true for grass as well as grain diets. This is also true for animal growth as well because cattle that are intermittently deprived of optimum intake of feed will have more efficient weight gains over time, but the total gain will be less than if the intake was at constant levels. Secondly, the heritability of postweaning gain is about .30-.35 in cattle, which means the environment is a key feature in the variation of actual weigh gain. Environments with only limited control such as pastures have a large influence response.

From a practical standpoint, pasture consistency must be maintained in spite of changes in animal needs and in plant growth. As cattle continue to graze through the plant growing season, they will undoubtedly increase in weight and maintenance needs. Thus, the amount of pasture dry matter needed for growth will continually increase with additional animal weight gain. The amount of pasture dry matter allocated to a set of cattle this week will not be enough next week to maintain intake and growth. Similarly, plant growth rate will often change with day length and rainfall. Pasture allocations will need to be changed to account for the availability of dry matter and(or) changing energy density in the plant.

Table 4. Production traits and pasture needs for grazing yearling steers

Trait	Pasture description
Growth	High energy, vegetative growth, maximum daily intake available
Marbling	Consistent availability, high energy, maximum intake
Fat	High energy, maximum intake, consistent availability
Muscling	Mineral needs met, protein value high, adequate intake available
Final weight	
Heavy	Consistent availability, adequate quality maintained
Light	High energy, maximum intake available

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Genetic Selection Tools for Improvement of Growth and Carcass Traits in Beef Cattle

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Introduction

There are many inputs that need to be considered by beef producers in order to make the correct decisions that will ensure a profit. One of the most important inputs to consider is the genetics that will go into the herd. This paper provides information concerning genetic selection tools that are available to producers to use in making sound decisions in the selection of genetics that will go into their breeding program.

Selection of Breed or Biological Type

There are significant average differences that exist between breeds in most of the growth and carcass traits. Therefore, a major genetic factor that must be considered involves the breeds that will be used in the breeding program. Cundiff et al. (1986) and Cundiff (1989) describe average differences between breeds for many traits of economic importance. Tables 1 and 2 provide a summary of comparisons for selected growth and carcass characteristics as taken from the paper by Cundiff (1986). The breed comparisons for growth and carcass traits were from F_1 crossbred calves produced by various breeds of sires and Hereford and Angus dams. For milk production and cow weight, the comparisons were from F_1 dams by the various breed of sires out of Hereford and Angus dams. From this table, it is evident that certain trade-offs must be made when considering breeds to use. Those breeds that provide higher average weights at weaning and yearling will also produce heavier birth weight calves as sires, which will contribute to increased calving difficulty. Higher growth breeds will also have larger average mature cow sizes, which will most likely lead to increased annual cow costs. On the carcass side, those breeds that have higher average marbling scores will also have moreaverage external fat, higher average yield grades, and lower average % retail product.

Which particular breeds will work best depends on many factors including the production environment for the cow herd, whether the producer sells at weaning or after backgrounding or retains ownership to slaughter, and the grid-based target if ownership is retained. DiCostanzo and Meiske (1994) provided a review of research evaluating the effect of differences in cow size and biological type on profitability. Table 3 is a table taken from the paper by DiCostanzo and Meiske (1994) that provides the maintenance requirements, expressed as Mcal Metabolizable Energy (ME)/Metabolic Body Size ($BW^{.75}$), and production traits of cows of various breeds. These maintenance energy requirements were derived from non-pregnant, non-lactating mature females. From table 3, it is apparent that breeds that have more potential for milk production and/or growth tend to have higher maintenance energy requirements. This means that larger cows, or heavier milking cows must wean a heavier calf to offset additional maintenance costs in order to be profitable. The challenge for cow-calf producers is to match the biological type or breed of cow to their production system to maintain acceptable reproductive rates, to produce growthy calves, and to minimize cow costs. In table 4, Ritchie (2001) provides four examples of matching cow genotypes to production environments. The bottom line is that as feed resources improve, cows that have greater potential for growth and milk production appear to be more profitable in the cow-calf sector of production. Both Ritchie (2001) and Gosey (Web Article) provide some general guidance on biological types that fit different carcass grids. Table 5, adapted from Gosey (Web Article) provides some general recommendations on the biological types that best fit three different carcass grid-based market targets. The take home message is that there is no single breed that will optimize profit for every production environment or grid marketing system that exists in the U.S.

Sire Selection

Once the breed or biological type of cow herd is selected, the producer will need to select the sires used in the program. This is important since most of the opportunity for genetic improvement through selection will be the result of the particular sires used. There is a tool available for the selection of purebred sires to improve both growth and carcass traits. This tool is called an expected progeny difference (EPD). An EPD is a prediction of an animal=s transmitting ability, or in other words, the ability of an animal to transmit genes to its offspring that will affect the offspring=s performance for a given trait. Expected progeny differences are used to compare animals within a breed=s data base for future progeny performance. For example, compare sire A with a 25.0 lb EPD and sire B with a -10.0 lb EPD for weaning weight. The difference between the EPDs of the two sires of the same breed means that if these two bulls were mated to a large number of genetically similar cows and the resulting calves raised under the same environmental conditions, the expected difference in the average performance of the calves would be the difference in the sires= EPDs (25- (-10) = 35 lbs), with sire A=s calves being heavier. Many breed associations provide EPDs for birth, weaning and yearling weight and milk. The milk EPD is expressed in pounds of weaned calf and predicts the ability of a sire to transmit genes for milk to his daughters that ultimately affect the weight of his daughter=s calves. Again for example, if the difference between milk EPDs for two bulls is 10 lbs, a producer using the two bulls may expect an average of 10 lb difference between their maternal grand-progeny weaning weights due to differences in the amount of milk produced by the daughters of the bulls. This assumes that the two bulls and their daughters were mated to genetically similar dams and bulls, respectively, and the resulting grand-progeny were raised under similar environmental conditions.

The usefulness of growth and milk EPDs as a tool for selection has been confirmed by many research projects. Studies by Hough et. (1985), Arnold et al. (1990), and Lykins et al. have demonstrated that EPDs can increase growth, can reduce birth weight while maintaining acceptable growth in calves, and can reduce calving difficulty. Meyer et al. (1994), Baker and Boyd (2003) and Brown et al. (2005) have shown that a high relationship exists between maternal weaning weight (milk EPD) and actual milk production. Meyer et al. (1994) estimated a genetic correlation of 0.80 between maternal weaning weight and actual milk production in two different populations of beef cattle. The research is very conclusive that selecting on the milk EPD will improve actual milk production in cows.

Many breed associations also have EPDs available for carcass weight, 12-13th rib fat thickness, ribeye area and marbling score. Two sources of data are available to generate the EPDs. One is steer carcass data that is provided via a designed sire progeny testing program. The other source of data is from live animal ultrasound measures of yearling seedstock (bulls and heifers). Ultrasound technology is used to measure 12-13th rib fat thickness, ribeye area and intramuscular fat within the ribeye muscle. Bertrand et al. (2001) reported that genetic correlations between ribeye area measured in yearling seedstock and ribeye area measured in young, finished steers is very high, when both are adjusted to an age-constant basis. The genetic correlations between measures of external fat thickness or intramuscular fat/marbling score between yearling seedstock cattle and finished cattle are not as high as for ribeye area. However, the correlations between these measures of fat in seedstock cattle and finished cattle are typically between 0.50 and 0.70, which indicates that the ultrasound measures on seedstock cattle provide valuable information to help predict carcass fat thickness and marbling score EPDs on an age-adjusted, finished steer basis.

Studies by Vielselmeyer et al. (1996) and Gwartney et al. (1996) reported results from the same project that demonstrated the usefulness of carcass EPDs. This project involved randomly mating six Angus bulls with high EPDs for marbling score and six Angus bulls with low marbling score EPDs to 180 cows whose breed makeup was 2 British, 2 Continental. Steers produced in the project were fed a growing diet for 48 days after weaning then placed in the feedlot; heifers were fed a growing diet for 191 days after weaning and then placed in the feedlot. Steers from each marbling EPD line were slaughtered at two endpoints (124 and 191 days of feed) and heifers were also slaughtered at two different endpoints (85 and 148 days on feed). The analysis of the data showed that there was no marbling line x sex, marbling line x endpoint, or slaughter line x sex x endpoint interactions, so the differences in marbling between the two lines were maintained regardless of the sex (heifers or steer) or the length of time in the feedlot. The average difference in marbling EPDs between the two lines was approximately 0.7 marbling score units. The actual difference in marbling score produced average across all sexes and length of feeding was 0.5. The marbling score in the study was 2.0 = slight, and 3.0 = small. An interesting sideline to the study was that the average growth and external fat thickness EPDs were not different between the sires used in the two lines, and the average fat thickness and yield grades were not different between the progeny produced by the lines. This showed that EPDs could be used to produce differences in marbling score without a corresponding increase in external fat or yield grade.

Usefulness of EPDs Across a Wide Range of Environments

In order for EPDs to be useful as a selection tool for the improvement of growth and carcass traits, it is important to evaluate if the differences in progeny performance across a wide range of environments can be predicted by EPD differences between sires. A project by Hough and Benyshek (1988) was conducted at the University of Georgia to evaluate the efficacy of using EPDs to select for growth. Hereford females in the research herd where the project was conducted were randomly allotted to two lines. One of the lines of females was mated to the same two Hereford sires over several years, where the sires in this line had yearling weight EPDs

similar to the national EPD mean based on Hereford National Cattle Evaluation results. Hereford sires used in the other line represented the top 1 to 2% of the proven sires evaluated nationally for yearling weight EPD. Calves produced from both lines were randomly assigned to two management groups after stratifying on sire. One management group received no supplemental preweaning nutrition; the other group had ad libitum access to a preweaning grain diet through the use of creep feeders located in the pastures. Creep feed was made available when calves were 5 months of age and continued for around 2-3 months until the calves were weaned. The creep feed consisted of 100% rolled barley that was fed for one month and then changed to 50% barley and 50% cracked corn until weaning. The cow herd in both lines was maintained on fescue and bermudagrass pastures in the spring, summer and fall. Winter nutrition consisted of fescue and bermudagrass hay along with corn and sorghum silage. Postweaning nutrition of both bull and heifer calves consisted of a high silage diet top-dressed with corn and sorghum. Heifer calves were maintained separately on a lower plane of nutrition than bulls. Analyses of the weaning weight or yearling weight data revealed that there was no selection line x management group or selection line x sex interactions. The difference between the progeny of the two lines was 14 and 28 lbs, respectively, for weaning and yearling weight and this difference was maintained regardless of sex of calf or management regime.

De Mattos et al. (2000) analyzed weaning weight records in Herefords using a multiple trait model that considered weaning weight as a different trait across different regions within the USA, and across Canada, Uruguay and the USA. The authors found that the direct and maternal genetic correlations for all pairwise country and region combinations were above 0.80, and that all genetic correlations across USA, Canada and Uruguay were as high as the direct and maternal genetic correlations across regions of the USA. Donoghue and Bertrand (2004) conducted a study to examine the existence of genotype by country interactions for birth weight, weaning weight and postweaning gain between Australian, Canadian, New Zealand, and USA populations of Charolais cattle. Again, a multiple trait model that considered each trait as a different trait in each country was fit to the data for pairwise combinations of countries. The direct and maternal genetic correlations between all pairwise combinations of countries for birth weight and weaning weight and the direct genetic correlations for postweaning gain were all above 0.80. Robertson (1959) considered genetic correlations that were greater than 0.80 for performance in difference environments an indication that genotype by environment interactions were not biological importance. The high genetic correlations between countries and regions estimated in the two studies by De Mattos et al. (2000) and Donoghue and Bertrand (2004) provide concrete evidence that sires would perform similarly to relative to each other in EPD performance for growth over a wide range of environments and countries. One caveat to this research is that genotype by environment interactions do not appear to be important across countries that are temperate in climate. However, genotype by environment interactions may be more important when tropical climates are considered.

In a study at the University of Georgia (unpublished data), six Angus bulls were selected to have marbling score EPDs that were above the breed average of Angus bulls being evaluated for carcass traits. In addition to these bulls, three Angus bulls that had marbling score EPDs below the average of Angus bulls being evaluated were also used . The high marbling line bulls had average marbling EPDs of .27 and the low line sires had average marbling EPDs of -.17.

Sires were randomly mated to commercial Angus cows and the resulting steer offspring were backgrounded and then place into the feedlot. Steers from each line were slaughtered at two times based on external 12-13th rib backfat measured via ultrasound. Average across the three years of data, the steers at the first slaughter time were on feed 95 days and had an average backfat thickness of .35 in; steers at the second slaughter time were on feed 148 days and had a backfat thickness of .56 inches. The average marbling scores at the first slaughter of the steers progeny from high and low marbling sires was 4.2 and 3.6, respectively. At the second slaughter, the marbling scores of progeny from high and low marbling sires was 5.0 and 4.3, respectively. The marbling score in the study was 2.0 = slight, 3.0 = small, 4.0 = modest. Gwartney et al. (1996) used many of the same high marbling Angus sires as the study in Georgia. They found that average marbling score of progeny from the high and low line sires average across all sexes and length of feeding times was 3.6 and 3.1, respectively. The differences between the high and low lines were similar across the two studies; however, the average marbling score in the Georgia study was an entire marbling score unit higher. In the study by Gwartney et al. (1996), the Angus sires were bred to cows that were 2 British, 2 Continental and the steers and heifers were slaughtered at two times around 14 and 17 months of age. In the Georgia study, the Agnus sires were mated to commercial Angus dams and the progeny slaughtered at two times around 20 and 24 months of age. Vieselmeyer et al. (1996), reporting on the same study as Gwartney et al. (1996), found that 17% and 52 % of progeny from low and high line sires, respectively, graded Choice at the first slaughter time, while in the Georgia study, 72 and 84% of the progeny from low and high line sires, respectively, graded choice at the first slaughter time. At the second slaughter time, Vieselmeyer et al. (1996) found that the 78% and 96% of the progeny form low and high line sires, respectively, graded choice, and in the Georgia study, 93% and 99% of the progeny from low and high line sires, respectively, grade choice. The results of these two studies show that the differences in sire marbling EPDs will be reflected in the marbling score differences of their progeny across a wide range of management and feeding regimes. However, using EPDs to predict the percent of progeny that will grade a minimum of low choice can be difficult since it may not be possible to predict the management and environmental conditions under which the progeny will be raised. The results of these carcass studies have important lessons for grass fed beef producers. Differences in carcass EPDs among sires will translate into observable differences in the carcass performance of progeny regardless of the feeding regime. However, if the objective is to place the majority of cattle into a low choice grade, using high high marbling sires may not produce the desired outcome if the feeding regime does not provide sufficient resources to lay down enough marbling to place animals into the choice grade.

Conclusions

Cow-calf producers have tools available to make sound decisions when determining which genetic inputs will optimize production and profit. The strengths and weaknesses of breeds have been fairly well characterized for important growth and carcass traits. After the breeds are selected for the breeding program, genetic values in the form of EPDs are available for growth and carcass traits to assist in the selection of seedstock bulls. EPDs provide a mechanism to

effectively rank seedstock bulls for future progeny performance across a wide range of environmental situations, including herds that feed cattle entirely on grass from birth to slaughter.

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Table 1 Breed Crosses Grouped Into BiologicalTypes Based on Paper by Cundiff et al. (1986) Increasing number of X=s indicate relatively higher weights or milk production.

Breed	Birth Weight	200-d Weight	400-d Weight	Milk Production	Cow Mature Size
Hereford-Angus	XX	XX	XX	XX	XX
Brahman	XXXXX	XXXX	XXXX	XXX	XXXX
Brangus	XXX	XXX	XXXX	XX	XX
Charolais	XXXXX	XXXXX	XXXXX	X	XXXXX
Chianina	XXXXX	XXXXX	XXXXX	X	XXXXX
Gelbvieh	XXXX	XXXXX	XXXXX	XXXX	XXXX
Holstein	XXX	XXXX	XXXXX	XXXXX	XXXX
Jersey	X	X	X	XXXXX	X
Limousin	XXX	XXX	XXX	X	XXX
Simmental	XXXXX	XXXX	XXXXX	XXXX	XXXX

Table 2 Breed Crosses Grouped Into Biological Types Based on Paper by Cundiff et al. (1986)

Breed	Carcass Weight	Fat Thickness	Marbling Score	Retail product (%)	Retail Product (lbs)
Hereford-Angus	XX	XXXXX	XXXX	X	XX
Brahman	XXXX	XXXX	XX	XXX	XXX
Brangus	XX	XXXX	XXX	X	XX
Charolais	XXXXX	X	XXX	XXXXX	XXXXX
Chianina	XXXXX	X	X	XXXXX	XXXXX
Gelbvieh	XXXXX	X	XX	XXX	XXXX
Holstein	XXX	X	XX	XXXX	XXX
Jersey	X	XX	XXXXX	X	X
Limousin	XXX	X	XX	XXXXX	XXXX

Increasing number of X=s indicate relatively higher weights, inches, score or %.

Table 3. Maintenance Requirements and Production traits of Cows of Various Breeds (Taken from DiCostanzo and Meiske (1994)

Sire breed or breed	ME_m, Kcal/lb	Body Wt, lb	205-d Milk Yield, lb	Weaning Wt, lb/d of age
Angus	53.5	1285	3131	1.71
Braunvieh	83.4	1263	3967	2.22
Charolais-x	58.5	1610	3153	2.30
Chianina-x	71.7	1359	------	2.96
Gelbvieh-x	78.9	1351	3733	2.17
Hereford	54.4	1302	3620	1.78
Jersey-x	65.8	1069	3313	2.45
Limousin	57.6	1276	2968	2.10
Red Poll-x	67.6	1126	3445	2.07
Simmental	60.8	1371	3529	1.98
Shorthorn	57.1	1089	4134	2.64
Angus	41.7	1109	------	-----
Brahman	42.6	1096	------	-----
Hereford	43.1	1078	------	-----
Holstein	52.6	1203	------	-----
Jersey	63.5	869	------	-----

Table 4. Examples of matching genotype to production environment[a] [a]From Ritchie (2001)

Production Environment Type	Genotype of Cow Herd
Restricted Feed Resources, Arid Climate	British x British
Medium Feed Resources, Semi-Arid Climate	British x Smaller, Moderate-Milking Continental
Abundant Feed Resources, Adequate Precipitation	British x Large, Heavier-Milking Continental

Sub-Tropical	Bos taurus x Bos Indicus

Table 5. General Biological Types That Best Fit Three Different Types of Carcass Grids[a]

Type of Grid Based Market	Type of Performance Needed	Best Performing Biological Type
Mainstream (55% of Market)*	Yield Grade 1s and 2s Low Choice and Select Zero Misfires**	2 Continental, 2 British For Southern Producers: Add ≤ 1/4 Bos indicus
Muscle (15% of Market)	100% Yield Grade 1s and 2s Tender & Low Fat Zero Misfires***	At Least 3/4 Continental
Marbling (30% of Market)	Mid Choice & Higher Yield Grade ≤ 3	At Least 3/4 British or British Cross < 1/4 Continental (selected for marbling)

[a]From Gosey (Web Article)

*Project scope of market based on 2000 Beef Quality Audit

**Misfires = yield grade 4s and 5s, standard quality grade, over or under weights, dark cutters ***Misfires = yield grades 3-5, Choice (depending on market), over and under weights, dark

THOUSAND HILLS
CATTLE COMPANY
100% GRASS FED BEEF

P.O. Box 323 • Cannon Falls, MN 55009

Todd Churchill, Owner (612) 756-1346 Fax: (507) 263-4019 todd@thousandhillscattleco.com

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How to Participate in the Market for 100% Grass Fed Beef

Thousand Hills Cattle Company exists to:

- Profitably serve the best eating, healthful, and safe 100% grass fed beef to educated and discriminating customers in the Upper Midwest.
- Raise awareness about the importance of diet, nutrition and quality food both to us and to our Creator.
- Create and nurture a profitable market for small-scale family farm and ranch-raised livestock.

To do this, THCC needs cattle at slaughter that:

- Produce "gourmet" eating experience beef
    - Robust, beefy flavor
    - Moist, juicy
    - Tender
    - Very limited connective tissue/gristle
    - High Select/Low Choice inter-muscular fat (marbling)
    - Wet and/or dry age well

- Yield a minimum of 65% meat to meat and bone ratio
    - Boneless meat yield range from actual carcass data since Sept 2003 is 58% - 65%.
    - Calculation: # lbs boneless meat / # lbs hot carcass weight

- Yield a greater percentage of high value cuts (loin, rib, round)
    - Variations of up to $300 per carcass at wholesale prices from same hot carcass weights

-
-
- Have gained weight consistently throughout their lives, especially the last 90 days.

- Are raised according to rigorous standards, allowing label and marketing claims meaningful to consumers, including third party verification

To provide cattle like this for slaughter, THCC Producers need three things:

1. Enhanced genetic potential

   At conception, each animal has a certain amount of "genetic potential" to produce a desirable carcass. This "genetic potential" can be compared from animal to animal, and predicted.

   This is why the working on cattle genetics is so interesting and critical. It is all focused on providing desirable carcasses. And desirable carcass qualities are tightly linked with desirable production characteristics:

   - Longetivity
   - Reproductive efficiency
   - Low maintenance requirements

   Please call Todd Churchill to talk further about your current genetics. THCC can help you source replacement heifers and bulls that will have enhanced genetic potential.

2. Minimize loss of genetic potential due to management and environment

   From the moment of conception, the environment and management practices are reducing the genetic potential that existed at conception

   Everything from mineral bio-availability, soil and forage quality, weather, animal handling, parasites, stress, weaning age and methods, etc. reduces the genetic potential.

   The combination of poor genetic potential and poor environmental and management practices requires that most cattle born this year will require high-energy grain finishing, antibiotics and hormones to produce acceptable eating beef.

   When these crutches are removed, we begin to realize how little we know about how environment and management affect desirable carcass qualities.

   Minimizing this loss requires several steps:

-
-
-
- Education – subscribe to The Stockman-GrassFarmer magazine (www.stockmangrassfarmer.net), attend conferences, including THCC sponsored producer events
- Develop a plan for raising high quality forages, and providing them to your cattle 365 days a year.
- Test your forage via plant tissue tests for mineral levels, brix, pH. Use this data to improve your forage and soils.
- Become proficient at low stress cattle handling and weighing.
- Weigh your cattle every 60-90 days to evaluate your forage.

3. A different attitude and business model:

- Willing to let go of what they learned, and what works in a commodity business

- Willing to open themselves up to feedback and accountability on carcass quality and yield.

- Willing to change their business plan (or develop one) to produce a differentiated product, not a commodity. (If you are selling into a value added market only in the low price years, you are still selling a commodity!)

- Possess a genuine desire to figure out how to raise beef that is exceptional in taste, tenderness, health benefits, and safety, and is highly desirable, even if it's challenging.

- Able to function and make decisions with ambiguity.
    i. We all know so little about maximizing genetic potential and minimizing the environmental and management impact on carcass quality and yield.
    ii. It is impossible to find consensus or agreement on these issues, even among the four key speakers at this conference.
    iii. Must be able to seek guidance from "many counselors", process it, and keep what will work for their unique production environment.

- Willing to focus on one of three viable production models:
    i. Birth-to-slaughter closed system
        1. Own cow herd, raise own herd bulls through A.I.

2. Have variety of land, topography, and soil quality suitable for cows and finishing cattle
3.
4.
5. Located in higher avg annual precipitation area, within several hours of Cannon Falls, MN.
6. Difficult to scale up – requires slow growth.
7. Requires expertise in both improving genetic potential and minimizing environment - management impacts on genetic potential – long learning curve
8. Offers more control over environment –management impacts on genetic potential.

ii. Cow/calf system
  1. Own cow herd, raise herd bulls through A.I.
  2. Ideal for more arid areas not suited to tillage and annual crops.
  3. Primary focus on maximizing genetic potential and minimizing environment – management impacts up to weaning.
  4. Partner with custom finisher by retaining all or part ownership of calves to slaughter.

iii. Custom forage-only finisher
  1. Don't own cow herd, in some cases, part owner of yearlings being finished.
  2. Ideal for "row crop" areas with higher rainfall
  3. Need tillable land
  4. Focus on development of a 12-month forage chain, combining perennial pasture with summer and winter annual grazing crops.
  5. Have excellent animal handling equipment and methods (Bud Williams – www.stockmanship.com)
  6. Can weigh all cattle every 60 – 90 days.
  7. Can accurately visually determine degree of "finish".

Protocols for Grass Fed Operations

Glenn Nader
University of California, Cooperative Extension

Production protocols are a valuable tool that can substantiate label claims, assure consumers of production practices, and standardize a product that is produced by multiple ranches. Grass fed protocols, with no supplementation, allowed many producers the ability to gain market share during the BSE case occurrence in the US. The protocol is the operational framework that third party certification can be based on. Given that a producers is attempting to connect practices that provides product value to consumers through a label claim, a review of customer product values should be the first step. Next is what are the management practices that can be implemented on your operation and provide an economic advantage. One needs to discern the net profit produced by each label claim. This will require a review of the label product premiums and the costs to the ranch operations to fit into the standards. Most producers have taken a less intensive study approach and look at how much they can place in the production protocol to add connection points to consumer and product value. These are some of the label claims in addition to grass fed that producers have included in their protocols: Natural, Organic, Humane Raised, Born and Raised in the USA®, and Predator Friendly®.

The nature of the marketing period is also going to be a great factor in the protocol. Most producers are attempting to provide a product year round, while others are offering a seasonal product. Most large retail chains are not interested in a seasonal product. Given the market dynamics, once they provide the self space and introduce a product to consumers, they want a steady supply. Restaurants, farmers markets, and other outlets can be ways of providing a seasonal market. The seasonal market generally provides a lower cost of grass fed production, as it is timed with the natural grass quality to fatten the animals.

Grass fed protocols have varied greatly with the past label definition of 80% grass and forage as the primary energy source. Also different grass availability and seasonal nutrient content have created a wide variety of protocols. In California, there are two grass sources available depending on the season. The coastal and inland valleys have green forage from February to June on non irrigated rangelands. The feed tends to be high in protein early and increase in energy later in the season (George, 2001). The forage quantity and quality is highly variable with the timing of rainfall and temperature. The second source of green feed is irrigated pastures that provides forage May to October. These pastures are generally cool season grasses and the bulk of the production is in the spring and fall. There are also native mountain meadows in the Sierra Nevada Mountains and in the northeastern California Intermountain area. This diversity of green forage provides many options for a grass fed protocols in California. The real challenge is to fatten the animals year round on feed of varying quality. To make this simpler to

achieve, many grass fed producers have selected medium to small frame animals with high carcass trait EPDs. Supplementing energy during certain times of the year has also been another way of providing a year round product. Large retail chains have demanded that the grass fed beef be a consistent product at all times in both taste and tenderness. With one grass fed operation that has over 40 ranches involved to provide the volume to sell in more than 150 retail outlets, a protocol that provides for 30 days of standardized feeding is the solution for consistency of taste. They also have a harvest age restriction on the calves to provide a younger tender product. The wine industry has a sales model that celebrates diversity in taste. Smaller grass fed markets could look at this model and attempt to replicate it in beef. This will simplify the production protocol, but may require more education and communication with the consumer. To work with the seasonal forage quality variability, one producer has developed a very simple business plan that allowed them to increase net income without all the complexities of selling a retail product. The producer's marketing plan is to sell the grass finished non replacement heifers and steers to customers on a live basis off the ranch in May each year. This has allowed them to use the natural forage to finish animals during the time of year that the range energy values are at their highest. They offer the purchasers the option of transporting the animals to a USDA inspected slaughter plant in one lot on a semi truck and then provide refrigerated semi truck transport back to one of two local processors for cut and wrapping of the meat to purchasers specifications. They require a prepayment to reserve the product and then final payment before delivery to the local processing plant.

Natural is a label claim that is non specific in its present wording. Protocols can specify the management that your operation is taking to provide a natural product to your customers. One study has shown that selling live natural weaned calves provided a 1.8 cent per pound gain from 1996 to 2003 in the western US (Nader 2005). At this price premium, it was established that the loss of weight gain by not implanting and the cost to sell the small pen lot of animals that required antibiotic treatment and no longer met the protocol was less profitable to the producer than traditional production. Many consumers have said they do not want meat from animals that have had antibiotics or implants. The real question is, what are they willing to pay for it and does it make up for the additional production costs.

Organic has been a small but steadily increasing label claim for beef (Clause 2006, USDA 2006). This is less expensive to add to most grass fed protocols. For those providing supplements to fatten, the cost and availability of organic feed sources has complicated logistical and financial operations. The challenges in most organic protocols are how to address parasite and fly management. Pasture rotation has been the management practice used to address internal parasites.

Animal-welfare labels have been developed recently to market meat products mainly to niche food retailers and restaurants. These labels on meat and egg packaging indicate that the animals were raised under humane conditions until they were slaughtered

(processed). Standards are developed by various animal protection organizations, which are usually higher than normal production operation. One such certification program is Certified Humane Raised & Handled, which is based on standards developed by animal scientists and veterinarians to provide a high level of farm animal treatment and care. Facilities are annually inspected to meet these standards and participate in the labeling program. More information on Certified Humane Raised & Handled can be obtained at http://www.certifiedhumane.com

Born & Raised in the USA®, has been a way producers connect to consumers with a value for a domestic product. The program provides a USDA-approved "trace-back system" to prove that the animal spent its entire life in the U.S. and was processed here. It is a certification process that allows the enrolled producer and retailer to use the trade marked label (American flag with Born & Raised in the USA). Producers will certify (on a herd basis) by affidavit that animals were born and raised in the US. Processing facilities will need to maintain identity of the animals (only as a lot) through the plant. There is a fee to enroll and then a per hundred weight charge to use the label at the point of sale. More information can be obtained at http://www.bornandraisedintheusa.com/usa_main.htm

Predator Freindly® is another connection point that may be of value to consumers interested in products that come from animals raised by ranchers and farmers who do not kill native predators on their land – coyotes, foxes, mountain lions, bears, hawks, eagles, or wolves. Predator Friendly growers reduce the risks of livestock losses by using guard animals such as llamas, dogs, and burros, and by using pasture management strategies to minimize confrontations between their animals and predators. For more information go to http://www.predatorconservation.org/

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Organic Grassfed Livestock Production and Marketing

By Angela Jackson-Pridie, MS

Introduction

The Organic Grassfed Beef market started to really come into mainstream after the serious Mad Cow disease fear was picked up by the media in late 2003. Consumers began to demand more information on how the cattle were raised and slaughtered. Additionally, organizations such as the American Grassfed Association and Jo Robinson of eatwild.com, were growing the awareness of the health benefits, safety, and preparation of grassfed meats. The marketing of organic meats started growing about the same time led by increased consumer demand. Consumers wanted the health benefits of grassfed and the surety that came with certified organic. So in 2004-2005, there was a surge of new producers who started converting and expanding to produce grassfed beef organically in volume and getting certified organic in order to realize the higher premiums over grain-fed organic or all-natural grassfed. In addition, retailers like Wild Oats and Whole Foods Markets began to add this product to their case ready and frozen meat offerings in their stores. Unfortunately, an imported organic grassfed beef product is still the primary source for wholesalers, retailers, and distributors primarily due to the inability to produce organic grassfed beef affordably and in volume in the US.

Overview

Organic farming has been one of the fastest growing segments of U.S. agriculture for over a decade. The U.S. had under a million acres of certified organic farmland when Congress passed the Organic Foods Production Act of 1990. By the time USDA implemented national organic standards in 2002, certified organic farmland had doubled, and doubled again between 2002 and 2005. Organic livestock sectors have grown even faster. ERS collected data from USDA-accredited State and private certification groups to calculate the extent of certified organic farmland acreage and livestock in the United States.

In 2005, for the first time, all 50 States in the U.S. had some certified organic farmland. U.S. producers dedicated over 4.0 million acres of farmland-2.3 million acres of cropland and 1.7 million acres of rangeland and pasture-to organic production systems in 2005.

Over 40 States also had some certified organic rangeland and pasture in 2005, although only 4 states-Alaska, Texas, California and Montana-had more than 100,000 acres. USDA lifted restrictions on organic meat labeling in the late 1990s, and the organic poultry and beef sectors are now expanding rapidly. Only about 0.5 percent of all U.S. cropland and 0.5 percent of all U.S. pasture was certified organic in 2005.

Fresh produce is still the top-selling organic category in retail sales. Organic livestock was beginning to catch up with produce in 2005, with 1 percent of U.S. dairy cows certified organic. Table 1 below breaks down the number of beef cows certified by state.

Table 1 - U.S. certified organic livestock, 2005, by State

State	Beef cows	Milk cows	Other cows/1
TOTAL	**70,219**	**86,032**	**58,172**
Alabama	-	-	-
Alaska	7,500	-	-
Arizona	-	35	-
Arkansas	-	-	-
California	700	13,535	4,619
Colorado	358	5,285	-
Connecticut	35	117	159
Delaware	29	42	-
Florida	-	-	-
Georgia	-	-	-
Hawaii	-	-	-
Idaho	3,245	4,325	1,161
Illinois	415	370	407
Indiana	167	237	70
Iowa	1,795	2,675	1,861
Kansas	695	-	158
Kentucky	12	61	40
Louisiana	-	-	-
Maine	329	3,743	3,350
Maryland	28	247	358
Massachusetts	36	37	44
Michigan	452	595	728
Minnesota	806	4,811	3,925
Mississippi	-	-	-
Missouri	5,540	2,385	7,372
Montana	1,387	-	104
Nebraska	828	67	661
Nevada	-	-	-

New Hampshire	25	177	-
New Jersey	111	4	-
New Mexico	35,396	-	-
New York	175	4,580	-
North Carolina	-	2	2
North Dakota	800	5	1,657
Ohio	342	1,893	969
Oklahoma	466	-	-
Oregon	103	7,829	8,199
Pennsylvania	650	5,705	3,280
Rhode Island	-	-	-
South Carolina	-	-	-
South Dakota	665	-	634
Tennessee	-	-	-
Texas	2,661	7,682	5,778
Utah	13	-	-
Vermont	-	-	-
Virginia	474	611	396
Washington	108	2,162	2,475
West Virginia	-	22	14
Wisconsin	3,204	16,793	9,716
Wyoming	669	-	35

/1 Includes unclassified cows and some young stock.
Source: Economic Research Service, USDA

Opportunities

Many U.S. producers are embracing organic farming in order to lower input costs, conserve nonrenewable resources, capture high-value markets, and boost farm income.

The generally accepted premiums for organic grassfed beef are anywhere from 30-60% over market depending upon the buyer and availability.

Chart 1 (below) depicts the organic grassfed slaughter weight cattle prices for 2005-2006. Compared to conventional slaughter cattle prices, organic grassfed slaughter weight cattle have averaged 45% more than the conventional cattle market. Direct marketing off the farm can realize premiums as high as 80% over conventional market prices.

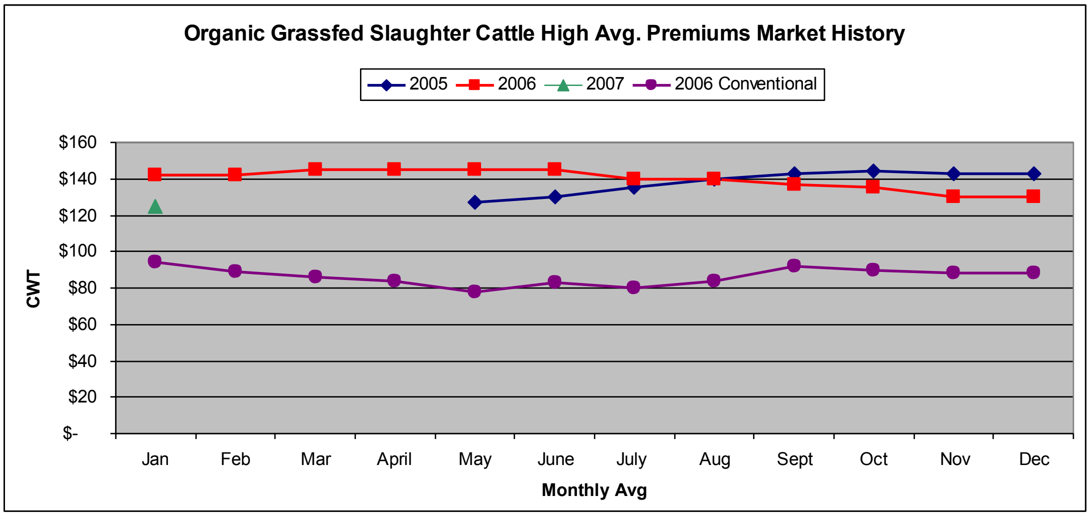

Chart 1. Avg. High Premiums for 05-06

The future demand for this product continues to increase at 12-70% annually depending on the market area within the USA, according to the Organic Trade Association. Demand exceeds supply by a large margin. For example, Whole Foods Markets needs 5,000 head of domestic organic grassfed cattle annually just for the Southern California stores and 15,000 head for the Southern region and is currently only able to source about half that according to local sources. The Midwest organic grassfed cattle production number for 2007 is approximately 5,000 head. Whole Foods Markets appears to be the primary retailer in the USA of this type of beef. The current market need is estimated at 25,000+ head nationally. The average pay price is expected to continue into 2007 at the current premium rates guaranteed to be no less than 30% over the Midwest conventional market averages according to current and local buyers.

Buyers of Organic Grassfed Beef

The largest volume buyer of organic grassfed beef is a broker located in Holdredge, NE. He is looking to source 5000 head annually for his current contract with a major health food retailer in the US. Currently he is sourcing about 2800 head and that is growing at 50% annually. Another growing buyer of this beef is Natural Acres located in Pennsylvania. They supply East Coast organic and natural retailers, wholesalers, and restaurants. Other buyers of this product are Maverick Ranch Beef, Blackwing, Panorama Beef, and Wholesome Harvest. However we have found a majority of organic grassfed beef suppliers are selling a blended product which is some portion of foreign produced beef mixed with domestic and sold at lower prices. There is a large volume of direct marketing to consumers and smaller distributors throughout the country moving the product to small health food stores.

Small, but growing

The U.S. organic market is still small. Retail sales topped $13.8 billion last year, making up approximately 2.5% of the market, according to Organic Trade Association. But organic sales have been growing about 20% per year with meat and dairy making up the largest areas of growth.

Once confined to roadside stands, farmer markets and food coops, organic foods have gone mainstream. Wal-Mart and Target began carrying organic this year. Half of the supermarkets nationwide are said to be experimenting with organic/natural formats. Even some grocers in the Dakotas have created organic sections.

Mintel, an international research company, predicts strong growth for organic sales over the next five years. Its analyst's project organic sales in constant dollar should rise 71% for meat, 45% for dairy, 31% for grains, 43% for prepared and packaged foods, 28% for snacks and 54% for vegetables in 2007.

Finding a market used to be a big worry for organic grassfed beef producers, but it is not that way anymore. It is not uncommon for an organic beef producer to get 5 calls a week from buyers looking for calves or finished cattle.

Constraints

Obstacles to adoption by farmers include high managerial costs and risks of shifting to a new way of farming, limited awareness of organic farming systems, herd health issues, shortage of organic livestock feeds, lack of marketing and infrastructure, and inability to capture marketing economies.

Other pitfalls and drawbacks continue to be drought, lack of consistency and tenderness, poor lipid profiles, long distance transportation, finishing, and management.

The biggest constraint to expansion is the lack of available "high quality" cattle certified organic to attract volume buyers.

Shortage of feed stuffs that are rich in protein and carbohydrates to cover the high requirements of the cattle during winter and forage deficit can cause nutritional deficiency with negative impacts on animal health and high costs of gain.

Climate, stocking density, nutrient needs, homeopathic treatments, and the high degree of variance between farms and regions make the availability of resources and management very difficult. There is a need for a high level of skills for managing the herd and resources within the farm region to manage the various demands and stresses. Good management strengthens preventive measures.

Under the current economic model, there are only a few options for organic farmers to hold their ground against the pressure of minimizing production costs. A lower performance level in organic compared to conventional production together with increased efforts and costs for rearing, feeding, and husbandry of the animals makes it even more difficult for the farmer to improve the situation. Apart from the current extra charge for organic products, there is urgent need for financial incentives and financing options to improve the current situation.

Limited availability of these resources and structural problems impede efforts to improve the status of animal health and quality of the beef at the farm level. When faced with conflicting aims and resource limitations farmers do not always give the highest priority to animal health. This can have a negative impact on beef quality and safety.

Lack of local processing centers is an additional strain on the system infrastructure. Organic beef kill slots are often difficult to schedule. Smaller plant closings are putting pressure on medium-sized plants to pick up the volume. Larger plants cater to volume brokers. Current organic plants lack the capabilities and equipment of larger plants such as USDA graders, auditors, scales, automation, and tracking. The infrastructure is not there to support large volume processing of organic grassfed cattle.

Currently organic cattle are being transported hundreds, if not thousands of miles, across the nation to processing plants to be killed and packed for large brokers. This added stress of hauling further degrades the quality of the meat and imposes health risks to the animal. The NOP rules, as written, do not address handling or transportation of live organic cattle from the farm to the processor.

Currently the USDA FSA office does not know how to asses the value of organic grassfed beef for organic farmers and beginning organic farmers loan programs. A national price index for organic grassfed beef does not exist. There are few financial incentives to help organic grassfed beef producers transition from conventional operations. The first three years of transition can be very costly since organic premiums cannot be realized often until the fourth year.

Other challenges are: industrialization, integrity, limitations of direct marketing, and lack of supply to attract volume buyers.

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About the author:

Angela is the Executive Director of the Organic Grassfed Beef Coalition, a collaborative effort of farmers and ranchers, researchers, livestock specialists, organic specialists, marketing specialists, and educators working together for the advancement and promotion of organic grassfed beef.

Angela has completed her Master's Degree and is a doctoral student at the University of South Dakota with an emphasis in organizational leadership, rural development, and information diffusion. She was head of a special marketing committee as a result of submitting a CSREES ORG Transitions grant to find a profitable market for organic grassfed beef. She reports and writes for many grassfed, farming, and organic publications. She frequently works with university research and extension. She sits on the New Farm Beginnings program in Nebraska, the South Dakota Organic advisory group, and recently joined the American Family Farm working group as part of the Ag of the Middle Program led by Dr. Fred Kirschenman. She successfully led the organic transition of the Robert J Pridie family farm from a conventional operation to organic grassfed currently certified by IDALS in 2005. She completed and passed her organic inspector livestock training and volunteers as an organic livestock consultant. She frequently speaks at regional and national sustainable agriculture conferences on organic grazing and organic grassfed beef livestock production. She was recently awarded a SARE Farmer-Rancher grant to research the constraints of finishing cattle on grass in an organic system. She has authored two successful organic grassfed beef programs and is working on writing her first book.

Making Organic Production Work on the Farm

Lynn Garling
The Pennsylvania State University

Introduction

In the past few years, interest in organic production in the United States has increased dramatically. Fundamental reasons for this increase include a rise in consumer interest in securing chemical-free products, thus creating demand and opening up new markets. Also, in 2002, the USDA implemented the National Organic Program (NOP) as mandated by the Organic Foods Production Act of 1990. This regulation defined the National Organic Standard, a specific set of production practices intended to define and harmonize what the term "organic" meant across the country. This National Organic Standard, the so-called "Organic Rule", now constitutes 61 pages of specific definitions, practices and procedures listed in the Federal Register. Today, being "certified organic" means producers apply to a certifying agent, follow specific practices allowed by the USDA-NOP in their operations, keep records of these practices and submit to an annual inspection to verify these practices, usually by a third-party inspector. Choice of which certifying body to use is up to the producer, since all certifying agents in the U.S. must now be accredited by and follow USDA-NOP rules in order to use the "USDA Certified Organic" label.

Where's the Organic Grass-fed Beef?

What does the growth in organic markets mean for grass-fed beef producers? Is certified organic for you? What are the "on-the-ground" considerations for such a decision?
There are at least 5 interrelated operational considerations that will determine if "going organic" is a good fit for your operation.

1) Philosophy and Attitude
2) Production System/Practices
3) Administrative
4) Financial
5) Target market(s)

1) Philosophy and Attitude

"Certified organic", legally speaking, means verified adherence to a specified combination of practices, so what difference do philosophy and attitude make? Big difference. By becoming certified, you are entering into a voluntary, legally-binding pact, promising consumers that you will not use prohibited substances or practices on your farm. In return, they will reward you by choosing your organic product in the marketplace. Despite the law, the whole system really relies on consumer confidence and producer and distributor integrity. With the opening of new markets and higher prices for organic products, many conventional producers are considering jumping on the organic bandwagon, while others (and their advisors) are standing on the sidelines throwing tomatoes. "Going organic" successfully requires an open mind and a willingness to comply with rules voluntarily on a day-to-day basis

Depending upon one's philosophy of farming, required organic practices that limit or prohibit use of antibiotics, hormones, synthetic herbicides and insecticides and synthetic fertilizers may be a totally new way of thinking, and thus, a constant burr under the saddle. Old prejudices about "hippies" and "tree-huggers" keep many from even uttering the "O-word". Worries about what one's farming neighbors might think seems to inhibit some producers from trying new things. All other conditions listed in 2-5 above may be in place for organic success, but if a producer does not have an open-minded attitude and "low-chemical input" philosophy, going organic will most likely not be a viable choice for him or her. The good news is, many graziers are 90% there already in philosophy, attitude and practice. So, what *about* practices?

2) Production System/Practices Considerations

There are many, many specific management considerations for organic production. Discussing them all in detail is beyond the scope of this talk – but I encourage those with serious interest to attend whole conferences on the subject, such as the Stockman Grass Farmer's yearly 2-day Organic Grass-Finished Production School. For now, I will discuss the following:

a) Summary of practices required for certified organic beef production
b) How do you know what substances are allowed/restricted/prohibited?
c) Production systems "conducive" to going organic

a) Summary of practices required for certified organic beef production

- **Three-year transition of land**
  If prohibited materials have been applied to the land, there is a three-year transition period from date of last application before the land can qualify for certification. In a perennial forage system, this need not require any additional cost, other than a time delay.

- **Adjoining land use and buffers, if needed**
  If there is a threat of contamination of organic crops with prohibited substances or GM genes from neighboring land, the organic producer must create an "adequate" buffer. What is "adequate" is decided by the certifying agency, with the help of the inspector's observations.

- **Use of organically certified seed unless not commercially available**
  - If organic seed not available; only untreated, non-GM seed allowed
  - No GM Rhizobium inoculant for legume seed

- **Access to pasture for ruminants**
  Luckily, this is easily accomplished in a grass-fed beef situation! Allowances are made for temporary confinement of animals due to weather, soil conditions, etc.

- **Slaughter animals fed only certified/allowed forages, grains, minerals, feed additives; including dams' diet from last trimester before birth of slaughter stock**
  Thus, brood cows may have originally been conventionally raised and so cannot ever be sold for slaughter as organic. As long as they are managed organically at least from the last

trimester of pregnancy, their offspring will be certifiable. Once transitioned, the brood cows must be managed organically from then on (so far).

• Only allowed substances on/in animals and ground (see next section, b)

e.g. health interventions (antibiotics, parasiticides)
e.g. soil/forage fertility amendments
e.g. building materials, fence posts (untreated)

Successful ecologically-based organic production relies on keen observation of the natural dynamics of the soil, plants and animals throughout the seasons and years and learning how to maximize the role each plays in sustaining the other. Ideally, use of "eco-smart" management practices will outweigh emphasis on external inputs or "organic" input substitution. The often posed question, "What can I use instead of product X?" might first be answered by "adjustments in management", if possible.

• Health records and a visible ID system for each individual animal

• Processing of animals only at a organic certified facility

• If your products are processed further, this too has to be at a certified facility, assuring no prohibited materials, ingredients or processes are used (e.g. ionizing radiation)

It is perhaps important to point out here that "certified organic" means that one follows prescribed practices in the production of a product, *not* that the end product is "certified free of synthetic chemicals" or any other specific "health" claim.

Regarding substances used in an organic operation:
b) How do you know what substances are allowed/restricted/prohibited?
The Organic Rule allows some synthetic materials, prohibits some "natural" materials and specifies the processes by which materials can be produced. Some materials are allowed for some uses (e.g. as a soil amendment) but restricted or prohibited in others (e.g. as a health intervention). Confused yet?? There are three ways you can find out about materials.

1) Read the Organic Rule, Subpart G – Administrative (206.600 – 206.607); "National List of Allowed and Prohibited Substances". Get more confused, then . . .

2) Call your certifying agency. Most certifying agencies have their own, much clearer, list of allowed materials and can help you understand what is going on in the rule. Most importantly, the certifying agency can tell you how THEY interpret the rule.

3) Subscribe to the Organic Materials Review Institute (OMRI, $50/yr; www.omri.org). Although OMRI listed materials are not recognized per se by USDA-NOP, most of the recommendations made by OMRI are consistent with the certifying agencies' interpretation of the Organic Rule. Final say on what IS allowed on your farm rests with your certifying agent.

A word of warning on materials:
The status of organic materials is constantly changing as new materials come on line, manufacturers change formulations, and/or lawsuits, petitions and political pressures change or add interpretations of the organic rule. To protect the status of your organic certification, you must CONFIRM ALL USES OF NEW MATERIALS WITH YOUR CERTIFYING AGENT **PRIOR** TO USE.
In general, do not seek or act upon information about the organic acceptability of specific products or practices from:
1) Your extension agent or university specialist
2) Your feed/mineral/ dealer or conventional consultant
3) Your neighbor
While these individuals all have valuable information to share, the majority are not up to speed on the details of specific requirements and status of allowed substances according to the NOP and your certifier. Meantime, you bear 100% of the risk of losing your transitional status or organic certification by using or applying something that cannot be taken back.

c) Production systems
Certain production systems and practices can make transition to organic more or less easy or difficult. During the presentation, I will spend time on each of the factors listed below and how they may affect ease or difficulty of organic certification. Generally speaking, for a well-established 100% grass/forage-based beef operation, complying with the *production* aspects of organic certification is a relatively easy next step.

Production factors influencing decision about "going organic":
- Land base and use (availability, cost, characteristics, size, location, crops cultivated)
- Animals (availability, breed, hardiness, efficiency on grass/forage)
- Labor (Got any? What kind and who? Partners, family members, hired help?)
- Infrastructure & equipment (animal handling facilities, heavy metal, light metal)
- Fertility and pest management practices (experience with non-chemical management)
- Health variables (quarantine areas, vector pressure, parasite loads, herd history)

3) Administrative Considerations
Organic certification requires a significant amount of administrative effort.
The key administrative commitments are:

a) Application to a certifying agency
Producers can choose from among dozens of agencies that provide certification services (more about that in Financial Considerations). Some are state-based; administered by state departments of agriculture (e.g. Maryland) or by an independent private certifier such as Pennsylvania Certified Organic (PCO). Many private state-based certifiers certify in multiple stages (e.g. PCO certifies in 9 states). Other certifiers are regional by design, like the Northeast Organic Farming Association (NOFA) or international, like Global Organic Alliance (GOA), Quality Assurance International (QAI) or Organic Crop Improvement Association (OCIA).

All U.S. certifiers require that producers pay a fee and fill out an Organic System Plan as defined in the organic rule. This plan consists of 6 parts and outlines the proposed operation including number of acres/animals, all inputs and management activities planned, maps with field boundaries and adjoining land uses defined, and field history records.

Besides cost, the most important consideration for producers in choosing a certifier is quality of service provided and responsiveness of the certifying agency to your needs – are they there when you need them? Currently, the best way to find this out is to ask other organic producers and consult some searchable databases (see references).

b) Recordkeeping

Organic certification requires good recordkeeping of on-farm practices including animal health records; crop production, yield, storage and sales; purchased inputs and their uses; and verification of sources of animals and feed. These records constitute an organic audit trail that is akin to a HACCP plan. The goal of recordkeeping is to ensure protection of the integrity of organic products from contamination or co-mingling with non-organic products and genetically modified (GM) content.

c) Inspection

Organic producers are inspected once a year by an accredited inspector assigned to the farm by the certifying agent. The role of the inspector is to verify what was written on the organic system plan (OSP); and to be the eyes and ears of the certifying agent. Inspectors are generally independent contractors, not employees of the certifier. They do not make any decisions about whether or not a producer will be certified. Inspectors sign a statement of confidentiality and are not allowed to discuss the farm operation with anyone but the producer and the certifier. Inspectors are not allowed to give advice on how to comply with the organic regulations - that is considered by USDA to be “consulting” and a conflict of interest. First-time inspections take anywhere from 3-8 hrs, depending upon the complexity of the operation.

4) Financial Considerations

A decision to go organic or not will be nested within the overall financial status of your farm, what kind of return you require from farming activities and your overall goals at this point in life. Not many producers in the U.S. today are actually making a living farming, and they haven’t been for a long time. The 2002 USDA Ag Resource Management Survey (ARMS) showed that only 7% of all farm operator households report getting all of their income from the farm. Nationally, farm operators indicated that on average, only 18% of household income comes from farming. Among farm types considered in the survey, cotton farmers had the highest income from farming and households managing dairy, poultry, beef, wheat and cash grains had, on average, the lowest. Organic certification is one strategy open to producers looking to take home a higher percentage of the consumers’ dollar.

The decision to become certified organic carries certain up-front costs.

a) Certification fees	$450-750*	Depending on the certifier; land/animals
b) Inspection fee	$150-350	Depending on the inspector, location, time.
c) Renewal fees	Variable**	

*Many states are taking advantage of a USDA cost-share program that reimburses producers up to $500 of the certification fees. Find out if your state participates. This is a big savings.
**Once you are certified, some certifiers charge and additional amount based on either % of organic sales in the previous year; number of acres in production and/or number of animals certified. Be sure to check into which system they use before deciding upon a certifier.

Also relevant to the financial aspects of organic certification is the question, "Is beef your only product, your cornerstone piece or an integral part of a diversified 'menu' of farm products?" It is possible to certify one aspect of the farm and not another; e.g. certify the land to make organic hay, but not certify the animals you raise on other parts of the farm. Certifying land is relatively inexpensive, while each animal enterprise added to the certification increases the costs. Whether these costs are justified will depend mostly on your market, described below.

5) Target Market Considerations

This may be the most important consideration for a producer considering organic certification. Despite stagnation in many farm market sectors, or volatility due to political/economic shenanigans (e.g. ethanol production's effect on corn acreage/price), the organic market is expanding domestically and internationally. Currently, beef is a relatively small part of that market (8%) but beef-eating consumers in this market want a healthy, humanely-raised, chemical-free product. Internationally, other countries seem to be eating our lunch in this regard – being more willing, or able, to do what it takes to get organic beef into the international market, and even bringing it into the U.S. Right now, there is a window of opportunity to meet a market demand but the mechanics of doing so on a larger scale in a highly concentrated industry such as beef is challenging.

Relevant marketing questions for a producer considering organic certification include:

a) Is beef your only product, your cornerstone piece or an integral part of a diversified "menu" of farm products? What role does beef play in your market?
b) How much effort are you willing or able to spend on marketing?
c) Where is your target market or niche?
- Direct to individual consumers (by halves, quarter or individual cuts)?
- Sell frozen product on-line?
- To retail customers (fresh or frozen)?
- By participation in a local beef coop?
- Sell on the commodities market?

d) Can you find a certified processor close enough to your operation/market?
e) Can you develop and sell "value added" beef products?

Generally speaking, the more direct contact you have with your own individual customers, the more margin you make and the less you "need" organic certification to sell your organic and/or grass fed product (provided they think you are trustworthy!). However, such sales are limited to how much face-time you can give to the endeavor; how much time you can commit to direct marketing; and usually, requires going into city markets to gain the top prices.

As you physically distance yourself from the individual customer, the importance of certification of your beef and beef products increases exponentially. These consumers can't see you and need the reassurance that a "certified organic" label confers. Being certified or not may well be the "edge" that differentiates your beef from the others. Think creatively about who *needs* your organic product and how to reach them (e.g. health-conscious groups).

If you are selling organic to a "remote" audience, it is also good to keep up with consumer trends. Consumers, of course, want it all. Quality, taste, healthy, convenient and as reasonably priced as possible. If the first 4 factors are in place, the discriminating consumer <u>will</u> pay a premium. CONVENIENCE seems to trump everything, so it is *very* worthwhile to investigate the "organic snack food, quick prep, pre-packaged" possibilities. This can add tremendous value/margins to your product, but requires significant effort to start up and carry out.

International organic markets, while increasingly important and lucrative, are currently difficult to access since Japan and the EU still do not recognize USDA standards across the board. Opportunities include working directly with international certification agencies or specific overseas buyers to meet their standards and establish a marketing relationship.

Organic – Yellow Brick Road or Highway to Nowhere?
Organic is big and getting bigger. For those producers who can successfully tap into this market, it can be the proverbial Yellow Brick Road. For those who cannot manage the 5 areas outlined in this talk, it is likely going nowhere. Can you make organic "work" on your farm? As a grass-fed beef producer, with a low-input philosophy, open-minded attitude and access to adequate land, your production changes, if any, are likely to be relatively minor. Your effort is likely to be10% each in production and administrative, 5% in financial with the remaining 75% spent on accessing markets. Only you will be able to determine if "going organic" will work for you.

References

For more information on U.S. organic standards, certifiers and resources, see:

Legislation: For a full copy of the Organic Foods Production Act of 1990, see:
http://www.ams.usda.gov/nop/archive/OFPA.html

Regulation: For a full copy of the federal National Organic Standards (Organic Rule) see:
http://www.ams.usda.gov/NOP/NOP/standards/FullText.pdf

(includes Subpart G – Administrative "National List of Allowed and Prohibited Substances"

For a list of entities that provide certification services, see:
http://www.ams.usda.gov/NOP/indexNet.htm
OR, to compare certifiers in a searchable database, see:
http://www.newfarm.org/ocdbt/
(Warning: double check with the actual certifiers for up-to-date information.)

For **excellent** background information, organic recordkeeping forms, decision-making considerations, including NCAT's "Organic Livestock Workbook – A Guide to Sustainable and Allowed Practices", see the Appropriate Technology Transfer for Rural Areas (ATTRA) – National Sustainable Agriculture Information Service website at:
http://www.attra.org/organic.html

Organic Materials Review Institute (OMRI) see http://www.omri.org

Independent Organic Inspectors Association (IOIA), see http://www.ioia.org

For international organic standards, trends and news see:

The Organic and Non-GMO Report" is a very informative bimonthly publication whose by-line reads "Information to help you capitalize on markets for non-genetically modified products", newsy, fact-filled format; a tad expensive at $60/yr for individuals. See http://www.non-gmoreport.com

International Federation of Organic Movements (IFOAM), an international federation of 700+ organizations involved in organic agriculture. Their purpose is to provide a platform & network for global exchange and cooperation on issues related to organic production. IFOAM has established production, processing and trading standards and an accreditation program for the regulation of certification agents. See: http://www.ifoam.org

Europe
The European Union (EU) established basic regulations for organic products in 1991, with adoption of Council Regulation 2092/91 and its subsequent amendments. The regulations apply to all food products marketed as "organic", "biologic", "ecologic", "biodynamic", or similar terms, in the 15 member states of the EU. The regs cover both domestic and imported products. Imports can be accepted either through approval of the exporting country's regulation; by approval of the inspection/certification body by the EU Commission or a member state; or by review of the certification documents which accompany each shipment on a case by case basis. The complete EU regulation can be viewed at: http://www.organic-research.com

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Japan Agricultural Standard, see: http://www.pure-foods.co.jp/index2.html

Economic Benchmarking of Grass Fed Beef Production

Allen Williams, Ph.D., PAS
Tallgrass Beef Company

- AMI Consumer Survey – 2007
  - 70% of consumers still purchase groceries at conventional stores vs "supercenters".
  - 21.2% have purchased natural and/or organic meats in past 3 months – up from 17% in 2006.
  - 25-39 age group most likely to purchase.
  - Key Drivers:
    - Better Health
    - Better treatment of animals
    - Better nutrition
    - Better taste
- Main hurdle for natural/organic meats – price.
  - 63% would buy more if lower priced.
  - 20.7% buy natural/organic exclusively.
- Areas of Improvement:
  - Top two factors -
    - Improved Quality and Increased Variety
  - Suggestions for Meat Department Improvement –
    - Better Pricing
    - More sales
    - Better quality, WITHOUT DECEPTION
    - Smaller portion sizes
- Predicted Future Beef Demand
  - Strong demand for consistent, high quality beef
    - Hotel and Restaurant market
    - Retail market
  - Export market will also demand high quality.
  - How will increased use of byproducts impact beef quality and consistency??
- Genetic Selection
  - Functional, fertile females
  - High quality end product

- Optimum Finishing
  - Target SE+ to CH product with 61%+ Yield
- Live Animal Carcass Ultrasound
  - Used to select Seedstock and Determine DTF

Tallgrass USDA Label Claims

- Grass Fed – No Grain
- Fed No Antibiotics
- No Hormones Administered
- Fed No Animal Byproducts
- Source Verified

Cow Efficiency

Why Worry About Efficiency?

- Impacts overall profitability.
- Includes fertility, growth, fleshing ability.
- Impacts spreading of fixed costs of production.

Cow/Calf Production Costs

Impact of Cow Mature Size on Efficiency: Nutrition

No. Cows[a]	Cow Mature Weight	Calf WWt	Pounds Feed/Day[c]	Tons/Hd/Yr.	Cost/Cow ($0.018/lb)
100	1000	510	25.0	4.56	$164
91	1100	530	27.5	5.02	$181
84	1200	580	30.0	5.48	$197
76	1300	600	32.5	5.93	$214
71	1400	6100	35.0	6.39	$230
67	1500	612	37.5	6.84	$246

[a]Assume 4 acres Fescue/cow on a year-round basis (400 acres).
[c]Based on 2.5% body wt. Consumption on a daily basis. Includes forage, hay, and feed consumption.

Impact of Cow Mature Size on Efficiency: IRM Valuation

No. Cows	IRM Projected % Calf Cropa	No. Calves Weaned	Cow Mature Weight	IRM Projected Calf WWTa	WWt/Cow Exposedb	$/CWTc	Total Value
100	87	87	1000	510	444	$117	$51,912
91	85	77	1100	530	448	$111	$45,299
84	84	71	1200	580	490	$106	$43,651
76	80	61	1300	600	482	$102	$37,332
71	79	56	1400	610	481	$100	$34,160
67	77	52	1500	612	475	$100	$31,824

[a]Based on Southeastern IRM data (Integrated Resources Management).
[b]Average weaning weight divided by no. of cows exposed for breeding.
[c]Based on OKC avg sale barn value (Feb. 2007).

Impact of Incremental Increase in % Calf Crop: IRM Valuation – Total Weaned Value

No. Cows	IRM Projected % Calf Cropa	% IncreaseOver Base	Cow Mature Weight	IRM Projected Calf WWTa	WWt/Cow Exposedb	$/CWTc	Total Value
100	87	0	1000	510	444	$117	$51,913
100	88	1	1000	510	448	$117	$52,510
100	89	2	1000	510	454	$117	$53,106
100	90	3	1000	510	459	$117	$53,703
100	91	4	1000	510	464	$117	$54,300
100	92	5	1000	510	469	$117	$54,896

[a]Based on Southeastern IRM data (Integrated Resources Management).
[b]Average weaning weight divided by no. of cows exposed for breeding.
[c]Based on OKC avg sale barn value (Feb. 2007)

Impact of Cow Mature Size on Efficiency: Grass Finished Valuation

No. Cows	Cow Mature Weight	No. Calves Weaned	Projected Steer End Weight	Retail Yield (lbs)a	Individual Steer Retail Valueb	Total Retail Value (Calf Crop)
100	1000	87	1050	399	$1596	$138,852
91	1100	77	1150	437	$1748	$134,596
84	1200	71	1200	456	$1824	$129,504
76	1300	61	1275	484	$1936	$118,096
71	1400	56	1340	509	$2036	$114,016
67	1500	52	1385	526	$2104	$109,408

[a] Based on 38% Retail Yield Average deviated from Live Weight.
[b] Based on Grass Finished Branded Beef Program average retail value of $4.00/lb.

Pasture & Feed Costs/Cow

Cost Center	Low	High	Avg
Pasture	$65	$90	$77
Crop Residue	$0	$6	$4
Harvested Forage	$40	$92	$66
NP* Raised Feed	$10	$45	$29
Purchased Feed	$25	$60	$49
Total Cost	$140	$293	$225

Operating Costs/Cow

Cost Center	Low	High	Avg
Operating	$40	$95	$72
Depreciation	$35	$52	$43
Capital Charge	$5	$47	$14
Labor Cost	$9	$52	$43
Total	$89	$246	$172

Total Costs/Cow

Cost Center	Low	High	Avg
Total Feed Cost	$140	$293	$225
Total Operating Cost	$89	$246	$172
Total Cost/Cow	$229	$539	$397
Calf Breakeven*	$0.36/lb	$0.85/lb	$0.63/lb

Forage Production Costs/Acre

Cost Center	Low	High	Avg
Land Charge	$25	$62	$32
Operating Cost	$53	$91	$75
Depreciation	$20	$32	$23
Principal & Interest	$0	$10	$2.50
Labor	$10	$45	$29
Total Cost/Acre	$108	$240	$161.50

Pasture Costs/Acre

Cost Center	Low	High	Avg
Land Charge	$15	$52	$24
Operating Cost	$7	$22	$15
Depreciation	$2	$8	$3
Principal & Interest	$2	$15	$2.50
Labor	$4	$18	$8.50
Total Cost/Acre	$30	$115	$53

Economic Benchmarking of Grass Fed Beef Production – Post Weaning Costs

Matt Cravey, Ph.D., PAS
Tallgrass Beef Company

Questions to Consider

- **What am I "good" at?**
    - **Cattle production**
    - **Marketing**
    - **Budgeting, economics, financing**

- **Can I learn to be "good" at areas that I may be weak in?**
- **Do I have resources or people that can shore up my deficiencies?**

- **Plan, plan, and plan some more**
- **Make decision**
- **GO! But, stay flexible**

Costs Associated With Growing & Finishing

- **Animal Cost**
    - **Weaned Calf, Yearling**
    - **500 – 750?**
- **ADG**
    - **1.5 – 2.0?**
- **Days to Finish**
    - **275 - 500**
- **Financing – carrying cost @ 8.25-9%**
    - **($125/hd equity)**
    - **About $0.1182/hd/day on $632.50 calf (550 lb @ $1.15) – finance $507.50 @ 8.5%**

Other Costs to Consider

- **Source verification**
    - **Tags - $1.00-$3.50/animal (EID + visual)**
- **Ultrasound?**
    - **$6.00-$10.00/animal**
- **Pasture Costs (seed, fencing, fertilizer, etc.)**
    - **$30-$115/acre**

- **Management & Labor**
  - **$$$$$$$**
  - **Extra employee(s)**
  - **Insurance**
  - **Truck**
  - **Equipment**
- **Custom Grazing Option**
- **Supplement ($0.05 - $0.14/lb)**
  - **Feed mill vs. commodities**
  - **Handling**
  - **Shrink!!!! Adjust price up to cover shrink**
  - **Program protocols**

- **Health & Prevention ($2 - $45/hd)**
  - **Program protocols**
  - **Vac 45?**
  - **Modified Live vs. Killed**
  - **Cost of "outs"**
- **Freight (In and Out?)**
  - **$2.50 - $3.25/loaded mile**
  - **E.g.., 200 miles @ $3.00 = $600/load**
  - **$600/44 head = $13.64/hd**
  - **$600/15 head = $40.00/hd**
  - **Your costs?**

- **Weigh up**
  - **Location of scales**
  - **Animal handling – low stress (dark cutters, shrink, bruising – trim loss)**
  - **Water and feed**

Feed Only Cost of Gain Pasture + Supplement

- **Weaning to Yearling (550-750)**
  - **$0.35-$0.50/lb gain**
- **Yearling to Heavy Yearling (750-1,000)**
  - **$0.50-$0.80/lb**
- **Heavy Yearling to Finish (1,000-1,250)**
  - **$0.75-$1.25/lb**
- **Average Cost Of Gain???**
  - **$0.40-$0.80/lb**

Medley of Challenges/Issues

- **Choosing harvest date**

  - **Sorting animals into load lots**
  - **When are they "done"? How do you determine?**
  - **Scheduling harvest**

- **How are you paid?**
  - **Live-weight vs. Grid**
  - **Carcass Data?**
  - **Timing of Payment**

- **Marketing Costs?**
  - **Time**
  - **POS materials**
  - **Advertising**

Cost of producing Commodity vs. Natural vs. Organic

  - **No implant (10-15%)**
  - **No MGA – heifers cycling (3-5%)**
    - **Steers vs. heifers**
  - **No antibiotics – "Outs" – alternative market**
  - **Natural & Organic Costs 20-60% higher**

  - <u>**Must receive higher price than commodity**</u>

We Are Paid On Pounds

- **Finish Weight**
  - **1,100 – 1,300 lb**
  - **Genetically driven**
  - **Moderation is important**

- **Dressing Percent???**
  - **53-60%**
  - **Gut fill is typically higher on grass fed animals vs. grain fed**
  - **Therefore, shrink tends to be higher**

Plan, Plan, and Plan Some More

The Devil is in the Details

Summary - Assumptions (Per Head)
550 lb. Calf @ $1.15/lb = $632.50

Item	Low	High	Avg
Tags/Source Verification	$1.00	$6.00	$3.00
Ultrasound	$0.00	$12.00	$6.00
Health	$2.00	$45.00	$23.50
Freight (In and Out)	$15.00	$50.00	$32.50
ADG to Finish	1.50	2.00	1.75
Total Gain	550	750	650
Finish Weight	1,100	1,300	1,200
Days to Finish	275	500	388
Interest	$32.50	$59.10	$45.80
Cost of Gain/lb (Feed Only)	$0.40	$0.80	$0.60
COG/hd (Feed Only)	$220	$600	$390
Dressing Percent	54	60	57
Hot Carcass Weight	594	780	687

Summary – Condensed Economics (Per Head)

Item	Low	High	Avg
Animal Cost	$632.50	$632.50	$632.50
Misc Costs*	$56.41	$164.29	$110.35
Feed COG	$220	$600	$390
Total Cost Per carcass	$909	$1,397	$1,133
Total Cost per Carcass, lb.	$1.53	$1.79	$1.65

Contract Grazing

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Successful investment in a livestock-forage system or the successful development of a pasture beef enterprise is dependent upon abundant forage resources. The forage resources may be personally developed or you may elect to utilize the services, expertise and forage resources of a contract grazer. Contract grazing allows the livestock owner to integrate resources into the operation as a means to stabilize cattle supplies or provide the opportunity to utilize forage resources or environments more suited to reaching market goals.

Cattle feeders in the Corn Belt have often taken advantage of growing calves by grazing small grains and cool season forages under contract. A grazing contract can be a valuable tool for regulating a continuous supply of high quality forages critical to a pasture beef enterprise. Contract grazing also provides a system for integration or retained ownership for the livestock producer. A grazing contract can be utilized as a grazing is a risk management tool to buffer the operation from the lack or surplus of grazing resources.

Most contractual arrangements are developed for financial reasons which may include the lack of capital, credit, or marketing access to remain independent. Contracts can improve the ability to secure credit for facilities or other capital improvements. For the forage owners (grazers) most contracts are part time ventures to supplement farm income. Contracts should not be treated casually. If the goals of the livestock owner are to be achieved, then the grazer must have a thorough knowledge of both forage management and animal husbandry. The purpose of entering into a contract is to achieve what both parties cannot do independently. Contracts are legally binding, therefore, before entering into a grazing contract the grazer should have several years of grazing experience and a proven track record of stockmanship.

Reasons for Contract Grazing

Contract grazing can provide a means for a pasture beef operation to integrate additional human and forage resources into the production and marketing plan. A grass fed beef enterprise has a number of contract grazing options from which to choose. Contract arrangements can be developed to graze the cow herd, grow and develop calves, or finish cattle. Utilizing contracts to maintain the cow herd on external lower quality forages provides the opportunity to develop and utilize high quality forages for growing and finishing calves on the home enterprise. Late fall and winter contracts that utilize stockpiled forages or grain aftermath for cows offers an opportunity to reduce the dependence on costly stored feeds and the capital investment in haying equipment. Replacement heifers can be contracted to better utilize the husbandry skills of an enterprise that specializes in heifer development therefore allowing the contractor to devote more time to marketing or other production tasks. If the base enterprise lacks the necessary forages resources to grow and finish cattle, the typical stocker or backgrounding contract can be utilized for the purpose of growing calves until they are ready to be finished. A pasture beef program with limited "finishing" forages may elect to develop contracts with a grazer that has a more favorable environment or forage resources that can be dedicated to the finishing phase. Cool mountain pastures or irrigated pastures are not available to all pasture beef enterprises. A grazing contract can reduce the need for land ownership, and allow for expanding facilities and skills without a large capital output. The utilization of contracts may also provide the pasture beef enterprise with a viable alternative to securing or developing additional employees. Contract grazing can add discipline, technical advice and technology to the grass fed beef enterprise. Contracts improve the knowledge and awareness of inputs and outputs. Contracts pool the resources of two or more individuals or business entities. Grazing contracts can assist with inventory control allowing for a steady product supply while providing a more flexible time table to market cattle. The contract grazer utilizes contracts to limit financial risk. The grazer may not be willing to enter into the risk of owning cattle and the associated problems of procurement and marketing. The grazer also benefits from the discipline and direction a contract provides. A successful contract grazers becomes a student of forage and environmental management incorporating the management technology that insures success. Contractual arrangements are about building relationships that are mutually beneficial to both parties. Teegerstrom et al. (1977) reported that when measures of economic optimization are applied, contract grazing is more likely to generate positive returns than owning stockers, which in turn generates better returns than cow calf enterprises. Contract grazing provided the grazer the most stable profits over time.

Contract Grazing Audit

Insuring a continuous supply of good quality forages is the goal of contract grazing. The grazer has to develop a management system to insure forage quality and quantity. A managed rotational grazing system is a management scheme that insures forages persist and perform, reduce erosion, and improve drought tolerance. A managed intensive system reduces the variability of net returns. There are a few essential items that should be present before entering into a grazing contract.

Stockmanship and grazing experience are key components for success. Too often a person inherits property and ventures into contract grazing with little or no experience. The results for both parties are disastrous. The inability to recognize the signals for environmental stress and/or illness will result in sub par performance. An evaluation of the grazing system and the type and quality of forages being maintained should be observed. If cattle run short of forage or provisions are not made to reduce the stress of the "summer slump", poor performance can be expected. Removal or relocation of cattle and the associated stress and expense will create hardships that are costly to both parties. The type of water system utilized will provide insight into the potential of the operation.

If water is available in every paddock and access is limited to ponds and streams then stress is minimized and performance improves. Handling facilities with scales conveniently located will insure that animal handling issues can be addressed in a timely manner and quality assurance is practiced. During the audit the terms of the contract should be discussed particularly noting costs, how the cost are calculated, what records will be maintained, payment schedules, and accounting. The duration of the contract must be defined. Too often, cattle are delivered too early or removed too late from pasture reducing gains and creating unassigned cost to the grazer. References for both parties should be supplied for review.

Contracts have always been a part of agribusiness. Contracts are self imposed rules. People enter into contracts in the course of daily living; many are oral agreements which express the intent of the parties. The daily operation of agribusiness commonly involves contracts. The buying and selling of supplies, products, real estate transactions, land and machinery leases, production contracts for feeding or grazing, feed grains and vegetable production contracts are ordinary business transactions involving the rules of contract law. A contract is a mutual agreement between two or more persons that govern conduct among transactions consistent with law and public policy. More simply, it is an agreement or set of promises which the law will enforce or the performance of which the law in some way recognizes as a duty (Williston1957).

Contracting has received mixed responses from livestock producers. Contracts are used by both large and small producers. Young farmers and many less experienced producers, have capital limitations and are more willing to utilize contracts than established producers. Older producers are more likely to feel contracting is a threat to their independence. Most producers that enter into contracting do so due to their inability to bear the financial risk independent producer. The development of marketing alliances and the sharing of resources through contractual arrangements allow smaller producers to remain competitive in the market place.
Contracts can be complex or as simple as both parties agree for them to be. Three points to remember about contracts: 1) must be equitable to the livestock owner and the grazer 2) contracts must provides protection to both parties 3) acknowledge actual cost of production, and provide an accurate and fair fee agreement (Fisher 1997).

Components of A Valid Contract
Certain components are necessary for a valid contract:

1.) Legally competent parties
2.) Proper subject matter
3.) Offer
4.) Acceptance
5.) Consideration

If any one of these elements is absent, there is no contract. In certain circumstances, an oral agreement may be a legal contract by which the parties in the agreement will be bound. The text of this discussion will be limited to a written contract.

1. **Competent Parties:** A person entering into a contract must have the maturity and have sufficient capacity to understand the significance of the contract. Generally, children, convicts and those considered mentally incompetent are not capable of making binding contractible agreements without court approval. Deficient mental capacity can arise from mental illness or even intoxication.
2. **Proper Subject Matter:** A contract lacks proper subject matter if the agreement involves illegal activity, such as a restraint of trade, gambling, or fraud. The parties named to the contract may agree to virtually anything they want to in the document, and the agreement will be enforceable as long as the contract terms do not require either party to do anything illegal or as long as the terms of the contract do not violate public policy.
3. **Offer** and 4. **Acceptance:** A mutual understanding or a "meeting of the minds" must be present before the contract can exist. Such agreements are reached through a process of offer and acceptance. Often counter offers and altering of conditions occur before an agreement is finally reached. Any questions that concern delivery, quantity, weight, price, quality, payment or any other things that affect the agreement should be settled.
4. **Consideration:** To be enforceable, a contract must provide consideration. The parties must exchange something of value; be it money, labor, goods, or a promise to do or not do specific things. A contract may come into existence when each party has promised something of value to the other or when one party actually performs part of the agreement in return for a promise from the other.

A person will not be excused from a contract that he or she has signed merely because he or she did not know the terms of the agreement. The person is held to have read and understood whatever was signed and will be bound by contractual obligations. It is not wise to sign anything that is not understood. Contract law is extremely difficult. For every rule there are many exceptions and complications so it is not advisable to rely alone on what is stated in this text when reading or writing a contract. Professional assistance can help avoid the possibility of serious and costly problems. Most grazing contracts tend to be simple and terms more straight forward than some production contracts utilized by the poultry or swine industry. A properly drafted contract will define the terms and conditions of the agreement. When drafting a contract, provisions should be taken to insure that guarantees are enforceable under the law.

Types of Contracts

There is little standardization of grazing contracts terms and conditions. Different types of contracts provide various methods for sharing cost, profits and risk. Contracts can be as variable as the situation dictates such as the type of animals to be grazed, or phase of production. Several basic types of contracts will be examined. The extent of usage of contracts varies widely over time and among the areas of the country.

Guaranteed Payment Contracts: These contracts guarantee a producer a specific payment regardless of the market price. The payment can be set up on a price per pound of gain or by the head or even a combination. The rate or price for gain varies with the agreed terms of cost of feed, labor, equipment, shrink, and market grade. The value of the contract is determined in the details. The livestock owner normally supplies the animals, feed, veterinary services, marketing, transportation and animal health supplies. The grazer will furnish the labor, equipment, facilities, utilities and enhancements that improve the performance of the animals. The livestock owner may or may not prescribe the management practices. Some contracts provide for bonuses or penalty depending on production performance. Cost of gain contracts exposes the grazer to some variables of risk including weather, quality and health of the animals. The right to refuse animals which appear to be poor risk should be addressed in the contract. Dates or terms for termination of the contract is very important since feed cost and the efficiency of the cattle declines as they mature and forage quality declines.

Incentive Contracts: Incentive contracts reward the producer's management and production ability to achieve high gains. Charges are made on a cost plus basis with payment covering feed cost plus a flat charge which varies with the gain achieved. Some incentive contracts for stockers reward the grazer by increasing the cost per pound as the cattle reach different thresholds of performance. For example the payment might start at $.25/lb for the first 200 pounds of gain per head but the rate changes to $.30 when the gain exceeds 200 pounds and improve to $.40/lb if gains over 300 pounds per head are achieved. Incentives for developing replacement heifers may add value to the payment if the heifers are bred AI or the conception rate exceeds contract expectations.

Profit Sharing Contracts: Profit sharing contracts are developed based on percentage contribution of each party. The income generated is divided proportionately. The arrangements often involve the contractor or investor purchasing the animals and the grazer furnishes the land, labor, facilities, and equipment. All risks are divided proportionately for profit or loss. One variation is to divide profits equally after all expenses are deducted. The grazer and contractor share price risk and production risk equally under this contract. A complete inventory and excellent records in the beginning and throughout the grazing period are necessary to properly calculate the contribution of each party.

Producers should evaluate the long term and short term benefits of a contract. Carefully analyze the contract to avoid potentially serious problems or economic losses. It is the ultimate responsibility of the person who signs the contract to know what he or she is signing and to take the initiative to become informed. The components in Appendix 1 should be addressed when developing and writing a grazing contract. Appendix 2 addresses considerations for a potential grazer.

Summary

Contract grazing is a legitimate agribusiness integrating human and forage resources into a production and marketing plan. The risk of livestock ownership can be reduces or shared through contract grazing. It provides an excellent method of marketing forages resources and stockmanship. The pasture beef producer may elect to utilize contract grazing as a means of business expansion or as an opportunity to utilize "specialized" forage resources and expertise not available to the enterprise. The opportunities are unlimited as long as mutually benefiting relationships are developed by the two parties. Contract grazing like any business follows a defined set of rules or guidelines that are legally binding. This document is designed to assist producers considering contract grazing as part of their production system. Forage contracts can be an economical means of reducing production cost and increasing profits by all segments of the cattle industry.

Appendix 1 **Grazing Contract Considerations**

1.) Identify all parties involved
    a. Define who owns the cattle
    b. Name the grazer to manage the cattle

2.) Define the duration of the contract

3.) Identify the cattle

4.) Death Loss
    a. Establish who pays for losses
    b. How to verify death losses

5.) Payment of medical, vet costs, minerals, fly tags, feed, hay

6.) Terms of delivery
    a. Detail number of head, sex, dates delivered, health, grade
    b. Provisions for shrink in and out

7.) Handling of undesirables
    a. Stags, pregnant heifers, bulls
    b. Realizers, chronics
    c. Animal disposition problems

8.) Payment terms
   a.) Define payment rates
   b.) Procedure to measure gain

9.) Right of inspection

10.) Terms for default
   a.) Conditions for termination
   b.) Actions to be taken in event of default

11.) Records and Accounting
   a.) Party responsible for accounting and records
   b.) Access to records

12.) Taxes
   a.) Who will pay personal property tax on cattle
   b.) Taxes and or rent on pasture

Appendix 2 A summary of considerations for getting started as a contract grazer.

1. What is your primary goal for your farm operation? Is it to maximize financial income? Is it to maximize environmental stewardship? Is it to simply generate enough money to “pay the taxes” and keep the farm from growing up? Is it to keep the farm in the family? Is to reduce labor? Is it to improve family quality of life? The bottom line is that you need to think about what you really want to do and how much risk you are willing to accept to accomplish your goal(s).

2. Risk comfort level. What level of risk are you willing to accept? Answers to this question must be related to the goals listed in Consideration #1 above. For example, if your primary goal is to improve family quality of life, your risk level could be higher. This would also be true if your goal is to maximize cash flow. If your goal is to minimize financial exposure, then contract grazing may be suitable for you.

3. What changes will I need to make to accommodate the yearling cattle that would be brought to my farm? Here are some points to think about.

   a. What is your level of stockmanship as it relates to yearling cattle? The reason for this point is that yearlings do not move or handle the same as a herd of cows.
   b. Are you able to identify the sick ones in a timely manner?

c. Do you have enough acres to at least graze a tractor trailer load (75-100 head)?
d. Do you have livestock handling facilities that are conducive to handling yearlings?
e. Do you have cattle scales on the farm or at least nearby?
f. If you have scales, do you have adequate pens to sort tractor-trailer load lots.
g. Do you have fences that are secure enough to provide confidence to the cattle owner that you won't lose any of their cattle?
h. Do you have a grazing management system that will convince a cattle owner that your operation should be able to add an appropriate number of pounds to the cattle? For example, a managed grazing system generally will produce more total pounds of animal gain than a continuous grazing system.
i. Do you or can you use electric fencing strategies? Electric fencing provides numerous grazing options and configurations that can help with grazing management.
j. What is your knowledge and attitude about mineral nutrition? Mineral supplements can help with gains and health. Your use and understanding of minerals can be a positive attraction for a cattle owner who is thinking about grazing on your farm.
k. Do you have plenty of well distributed clean, cool, water systems? For optimum gains cattle should not have to walk farther than 800 feet for water and the water should be cool and clean.
l. What is your level of soil and forage management? Your best forage production can only be achieved with proper soil fertility management.
m. Do you collect soil samples regularly; ie. every 2 or 3 years? If the cattle owner knows that you are taking care of your soil resources, he has a good idea that the forage resources that you will offer his cattle will be acceptable. It also give you confidence that you can earn some money with a grazing enterprise.
n. Grazing for weight gains is different than grazing for weight maintenance.
o. How well do you know the forages that are growing on your farm? Different species need managed differently. Some can be grazed closely with little damage to the stand while others must not be overgrazed if you want to keep them in the stand. Some species lend themselves well to grazing after killing frosts while others do not. This becomes important if you begin to think about grazing late into the fall season.
p. How much time are you willing to spend to manage this contract? In other words, what level of "service" are you willing to offer the cattle owner? Can you convince the cattle owner that your farm is where his cattle should be grazing?
q. What is the farm's history for cattle deaths?

r. How flexible are you? Are you willing to load out heavy animals early and accept new animals at different times throughout the grazing season?
s. Are you willing to keep timely accurate records? Records are important to help answer any questions you or the cattle owner may have.

Appendix 3 Sample Grazing Contract

This agreement is made this ___________ day of ____________, 200____,
between __________________
Hereinafter referred to as "Grazer", and ____________________ of
_____________________, hereinafter referred to as "Owner".

WITNESSETH:

______________________________ owns a grazing operation in _________________ County, West Virginia, where livestock is cared for and grazed for the account of others as a custom grazing operation and not as a public stockyard. Owner anticipates that it will, from time to time during the term of this contract tender cattle to the Grazer for such care and grazing.

Now therefore, Owner and Grazer mutually agree as follows:

1. The term of this contract shall be from the date, _________, until terminated by either party by giving the other party not less than _______ day advance written notice from the date of placing the last animals on the grazer's farm. Any management "put and removal" schemes will be agreed upon and attached to the contract.

2. The Owner shall give Grazer ample notice of the approximate number and the estimated arrival time of any cattle to be tendered hereunder, and Grazer shall be required to accept such cattle provided agreement thereon is reached between Owner and Grazer prior to shipment. After acceptance of the cattle by the Grazer, Grazer shall have the right to reject any cattle tendered hereunder if such cattle have a contagious disease or injury. Owner warrants that it will be the legal owner of and cattle tendered hereunder and that its title to such cattle will be free of any encumbrance whether by conditional sales agreement, mortgage or offense, not disclosed on writing to the Grazer prior to the Grazer's acceptance of the cattle. The word "cattle" unless provided to the contrary shall refer to cattle subject to this agreement.

3. The contract Grazer agrees to hold, care for and graze cattle during the term herein, unless prevented from so doing by condition beyond his control. In

4. the absence of written agreement to the contrary, cattle will have access to forage as Grazer deems appropriate, but the Grazer does not guarantee the results. The contract grazer shall keep correct records of amounts and cost of supplements, trace minerals or treatments provided. The Grazer may brand or otherwise identify cattle for purpose of identification. Owner shall have the right to withdraw any and all cattle at any time on agreed advanced notice to the Grazer and upon payment of all grazing expenses and other charges hereunder up to the delivery date. Delivery to owner shall be made at Grazers farm or other mutually agreeable locations.

5. Owner agrees to pay Grazer in accordance with the attached schedule of grazing charges, receipt of which the owner hereby acknowledges and the Grazer agrees to adhere for the contract term. Owner agrees to pay all property taxes on cattle, and if owner fails to do so before they become delinquent, Grazer may pay them, in the event Owner shall be obligated to reimburse the custom Grazer for any such taxes (and penalties) so paid by the Grazer. Owner also agrees that in the event any of the Owner's cattle die while in the possession of the Grazer to reimburse the Grazer for any cost incurred in disposing of the remains of said cattle. Any expenses incurred above the grazing fees shall be paid within 30 days of receipt. The Grazer shall have the right to require all charges up-to-date to be paid before delivering cattle to Owner hereunder. In the event Owner fails to pay all charges when due, after demand by Grazer, Grazer shall then have the right, at its election, to the extent not prohibited by law, to sell Owner's cattle at public auction or private sale, with or without notice to Owner, F.O.B. and C.O.D. at the Grazer farm, at such price as is reasonable obtainable under the circumstances, and with the right in itself to be the purchaser at any such public sale, and from the sale proceeds obtained Grazer shall then reimburse itself for the cost of such sale, including any reasonable attorney's fees minimized, then apply the balance to all accrued charges of Grazer to Owner, and hold any remaining balance for credit to Owner. If there remains any deficiency on such charges, Owner shall immediately pay the same.

   In addition to all remedies and liens provided by law, the Grazer shall have a specific lien on cattle to seize payment of all such charges. Should the Grazer release from its possession any cattle prior to receiving payment for all such charges, Grazers lien for such charges shall continue on cattle remaining in its right to all proceeds obtained from the sale of such released cattle until all accrued charges of the Grazer to Owner, of any nature, are fully paid.

6. Risk of loss of cattle shall be upon Owner for the first 21 days from day of receipt. The Owner and Grazer shall share loss or death of cattle not covered by insurance on a 50:50 basis determined on average purchased value on the

7. remainder of the contract. The (Owner or Grazer) agrees to carry insurance on cattle for catastrophic losses such as lightning, floods, dog or predator damage. In case of death of any cattle, Grazer will promptly notify the Owner and dispose of such dead cattle in a manner practicable and within regulations of the state of West Virginia.

8. The Grazer is authorized to employ the services of a veterinarian for attendance upon any or all cattle when in the judgment of the Grazer such services are necessary or advisable. The cost for such veterinarian, together with the cost of medicine and all necessary supplies incident to treatment of such cattle, shall be (charged against the Owner). If in the veterinarian's judgment any or all animals should be disposed of, the Grazer, subject to notice the Owner except in extreme emergency will act as the Owner's agent in proper disposal. The Owner hereby ratifies and approves any such treatment or administration by the Grazer of any of the Owner's cattle previously placed with Grazer, which may still be under Grazer's care and control.

9. Owner agrees to deliver healthy, fresh cattle that have been vaccinated (see attachment) uniquely identified, castrated, dehorned and treated for internal and external Parasites at Owners' expense. The Grazer hereby agrees to de-worm and re-implant cattle at Grazer expense as implied on attached management program. The Grazer will be responsible for accrued cost and treatment of pinkeye, foot evil and any growth promotion supplements as to enhance the performance of the cattle. The Owner is responsible for all transportation cost to and from the Grazers' farm or scales. The Grazer assumes cost of assembling after cattle have been delivered.

10. The Grazer agrees to receive and calculate weight gains from delivered weights at the farm. Cattle will be weighed off at termination of the contract with an early morning weight and a 2% pencil shrink.

or

The Grazer agrees to accept and receive cattle weighed at point of origination and delivered within 24 hours as initial weight for determination of gain. Cattle will be weighed off at termination of the contract at daybreak with no pencil shrink.

11. Time is the essence of this contract. The waiver by the Grazer of any break by Owner of any provision of this contract shall not be claimed to be a waiver of such provision or a waiver of any prior or subsequent branch of such provision, nor shall the acceptance of any payment after it is due constitute a

waiver of Grazer's right to require that after payments be made when due. In the event Grazer shall bring any action in any court by reason of this contract or to enforce any of the Grazers' rights hereunder, Owner shall be liable to pay Grazer reasonable attorney's fees to be fixed by court. Any notice by certain party to the other may be given by mail addressed to such party at the address set forth opposite such party's signature at the end of this contract.

12. This contract shall be construed and enforced in accordance with the laws of the state of West Virginia.

In witness whereof, the parties have executed this contract in duplicate the day and year first above written.

OWNER	CUSTOM GRAZER
________________________________	________________________________
ADDRESS	ADDRESS
________________________________	________________________________
TELEPHONE	TELEPHONE
________________________________	________________________________

ATTACHMENT _______________ DATE _______________________

Appendix 4 CUSTOM GRAZING PAYMENT SCHEDULE

Payment for gains will be established on an incentive slide. The first 200 pounds/head will be the base at which the cost of gain will be $.20/lb. for steers and $.24/lb. for heifers.

For each 50-pound increment over 200 lb/HD will readjust the payment price.

GAIN/HD	STEERS PAYMENT/lb.	HEIFERS PAYMENT/lb.
0-200	$.20	$.24
201-250	.22	.25
251-300	.25	.30
301-350	.30	.35

EX. Steers gaining 200 lb/HD return $40.00/HD to the grazer.
(200 X $.20 = $40.00)

Steers gaining 265 lb/HD return $58.30/HD to the grazer.
(265 X $.25 = $66.25)

ANIMAL HEALTH SCHEDULE

Prior to arrival (Owner's)

1. IBR PI3 BVD
2. Lepto 5
3. 7 Way/Somnus
4. De-worm
5. De-loused
6. Identified
7. Pinkeye
8. Implanted

Post Arrival (Grazer's)

1. De-worm 30-40 days
2. Re-implant 60-90 days
3. Rumensin or Bovatec

CUSTOM GRAZING FOR GRASS FED BEEF PRODUCTION

Kevin Fulton

Fulton Farms is located in the loess hills region of central Nebraska approximately 8 miles north of Litchfield. The farm consists of 2800 total acres with approximately 2300 of those being native rangeland along with 500 acres of cropland of which 450 are irrigated acres. The majority of the cropland lies in the Clear Creek valley covering one of the deepest areas of the Ogallala aquifer. In 2001 we started plans to convert all of the tillable crop ground into grazing land utilizing perennial pastures and annual forages. Our last grain crop was harvested in 2004. We have created a forage chain that allows us to grow and finish cattle on grass. In addition to our grass finishing enterprise, we also run a cow/calf operation consisting of purebred Galloways. We are in the process of adding several other grass based enterprises as well. We have a small goat herd, some horses, and plan to introduce pigs, sheep, and dairy enterprises in the near future. We are currently making a transition towards a certified organic status and will have some of the farm certified this year (2007). The farm is basically a one man operation but I usually employ an intern or full time employee during the summer months.

We have been grass finishing cattle since 2003 with approximately 1000 head of cattle moving through this system in the last four years. During this time period we have marketed these cattle through six different outlets. We have worked with many producers and have finished numerous breeds and bloodlines of cattle. This has been an education for us and we continue to learn more everyday. In working with these different entities and various types of cattle, we have gained valuable insight into all facets of the grass finished beef industry. Along the way we have formed partnerships with numerous producers as well as with companies who market the products. We have finished cattle using various arrangements. We finish most of the calves that we raise, we partner on cattle with other producers and we custom finish cattle for producers and/or beef companies. We also custom graze other classes of livestock besides grass fed beef.

Custom grazing and finishing is an enterprise that has allowed us to utilize our entire land base without having large sums of money tied up in cattle ownership. Generally there is less risk involved and cash flow is greatly improved. It can also give you greater flexibility when it comes to matching cattle numbers with forage availability. This is especially helpful during drought conditions like we’ve had in Nebraska for the last 6-7 years. This past grazing season (2006) we had 1800 head of cattle grazing at one point early in the grazing season but had to reduce this number because of severe early heat and drought conditions. We were able to do this without selling any of our own cattle.

Economics

The first thing most producers always ask me is what we charge for custom grazing. Others want to know how many cattle we can run on an irrigated pivot or how profit levels with grass stack up against the most popular crop grown in our region, which is corn. I believe most people are skeptical of what we are doing. After all, we took highly productive corn ground and turned it into a pasture! The answers to the questions above are not that simple because there are so many variables that need to be factored in. This is no different than other types of farming. It will also vary greatly from farm to farm. However, I will state that in general grass farming potentially is much more profitable than raising commodity grain crops. Inputs can be greatly reduced, particularly machinery, chemical, and seed costs. Ironically, I believe that the reduction in machinery needs is what keeps many a young farmer from considering grass based farming. We live in an era where he who drives the biggest equipment and farms the most acres wins, or at least develops a certain perceived status level. With harvesting a crop I realize there is no glory in moving polywire fences when compared to driving a $300,000 combine. But considering the differences in payments and depreciation on large machinery vs. portable fencing material, it would behoove many farmers to consider a grazing operation.

When it comes to grass finishing on a custom basis you are basically providing a service to someone who is retaining ownership on their cattle. They have hired you to finish their cattle for them which is already commonplace in the feedlot industry. From this standpoint grass finishing is very similar. This is why we have evolved to our current pricing structure where we charge the customer for the feed the animal eats and our management and whatever other inputs are used. We have used other methods such as a cost of gain basis, set daily fees, etc. but our current formula has worked best for us. After all, there are good reasons why the feedlot industry does not use the previously used methods and the same pitfalls apply to a grass finishing situation. If you can convince a feedlot to feed your cattle using a cost of gain charge I would consider you exceptional at the art of persuasion. Keep in mind that some potential customers will tell you that they have great cattle that have done well in the feedlot or even on grass. The cattle may have been linear measured, ultrasounded, or given the stamp of a approval and forward contracted with a grass fed beef company. They may be using the best grass type bulls from a reputable producer. Even so, we have found that none of these things in themselves guarantee much predictability when it comes to gain. The only real predictor of gain performance will come from cattle that you are raising on your own farm at the same location as your finishing operation. The next best situation would be cattle that were raised in close proximity to your operation under similar management styles. Any time you take animals and put them in a different environment there will be an adaptation period which usually includes stress that starts with the truck ride to their new location. This can adversely affect performance even with the best genetics. In general we will get about 1.75 to 2.25 lbs. ADG on large groups of cattle over a 180-200 day grazing period. This will include an adaptation period, summer slump, high heat and humidity and other adverse conditions. We get our best gains in late spring/early summer and in the fall. There can be a wide range of performance within any group of cattle. We have seen some cattle gain 3.5 lbs while others gained 1/2 lb. Sometimes you may hear of people who boast of high ADG values but many of these should be treated with skepticism. High gains can certainly be achieved under the right conditions but usually this is a short term scenario and/or with certain small select groups of livestock that were already adapted. What really matters is how the animal performs over the long haul, from weaning time until it has reached a finished weight. Some farmers cannot resist the temptation to add to their yield or gain figures. While boasting to your peers, 220 bu/acre sounds so much better than the 195 bu./acre actual yield. But surely graziers would not fall to such temptations.

Our pricing formula for grass finishing is as follows:

(weight of the animal) X (forage intake) X (forage price) + daily mgmt. fee

Here is an example:
A 700 lb. steer consuming 3% of his bodyweight in forage valued at $65/ton with a 15 cent/head daily management fee would cost:
700 X .03 = 21 lbs. X 3.25 cents = 68.25 + 15 cents = 83.25 cents daily charge.

These are some actual values that we will be using for the 2007 grazing season. The advantage of this formula is flexibility. The animal can be re-weighed at any given interval to adjust for an increase in bodyweight which will change the consumption value. We generally do this every 90 days. We also change the values depending on the season. We have two seasons for this formula, the growing season (summer) and the dormant season (winter). During the winter season (November-March) our forage price and management fee will increase because we are feeding stockpiled forages and/or hay and management becomes more difficult and costly through Nebraska winters. The forage cost is generally based on current local hay prices. This formula is fair for both parties and the customer gets what they pay for. Even though we do not guarantee gains there is a built in incentive for us to manage the cattle for optimum performance. If they are gaining we will be able to increase the daily fee accordingly when the cattle are re-weighed and increase the bodyweight value. Good performance also assures repeat customers.

We know that it costs us a lot more to put gain on a 1000 lb. animal than it does on a 700 lb. animal. Since we can put gain on cheaper with the lighter animals, we can pass along that savings to the customer. On the other hand they will have to pay more for the added

cost of gain with the heavier animal. We used to charge based on per pound a gain. Unless you adjust for bodyweight this method works great for light cattle but you lose money if you have the cattle until they are finished. This can lead to an open invitation for people to bring you heavy cattle towards the end of the grazing season for you to finish after they have put cheap gain on themselves. We have also had grass fed companies keep us in a holding pattern with cattle grazing that are already finished, simply because they aren't ready for the meat. We call this live animal storage. You may hold the cattle for weeks with very little gain while they are consuming large amounts of your forage. Our formula alleviates this problem because they are paying for that forage and your labor so you are fairly compensated for this storage fee.
This winter our forage value was $110/ton and the management fee was 25 cents/day.
Therefore wintering a 1000 lb. grass fed steer would cost :
100 X .03 X 5.5 cents + 25 cents = $1.90/day

This is not cheap! But if you think it is unreasonable, then you need to take a group of heavy steers through a Nebraska winter on forage alone and you will find out what it costs and the work involved. I realize that you can get custom grazing contracts for cows on grain residues through the winter here in Nebraska for 50 cents/day with full care. However stockpiling grass and hay feeding while trying to fatten an animal is a whole different situation. Because of reduced gains through Nebraska winters, most years it is probably not be economically feasible to do this. There are several ways to reduce this problem. One is to have the animals finished before they go through that second winter at a heavy weight. This may mean adjusting calving periods and changing genetics. The cattle owner should also demand a higher premium for cattle finished and delivered during the winter months. Typically there is a shortage of grass finished cattle during that time of the year. You may also want to consider sending the cattle south where they can graze on green forages all winter and avoid extreme cold temperatures. Feeding grass silages can also help. Although it will not reduce feed costs it can help improve animal gain which will improve your cost of gain. The solution that many have taken with wintering grass fed cattle or taking them through drought conditions has been to use grain, grain by-products, and other non-grain by-products to provide energy and improve animal performance. Without current labeling standards for grass fed beef, this is all perfectly legal even though it can be very deceiving to the consumer. I have seen some people supplement with small amounts of these products while others use them for a high percentage of the total ration. Some of these products contain starch, some do not. We have never used grain or any of these types of products on our farm for grass finishing cattle so I cannot comment on the economics of their use. Our own cattle are marketed as 100 % grass fed beef so it would be difficult for us to go this route even with custom grazed animals. It would lead to managing herds separately and animal confinement. With our move towards certified organic, there is no need to get started relying on these practices anyway. From a logistical standpoint we do not have the labor or equipment resources to make this work. We have a labor force of one, and we have no feedbunks, feedwagons or feeding facilities of any kind on the ranch. And we do not intend to acquire any of the above. I did not get into this business to run a feedlot which is what some custom finishers in the grass fed industry are doing. We also help our customers get their cattle marketed with the various contacts that I have. If we feed by-products to their cattle it would reduce the number of options we have to market the animals. Each company has its own set of standards and protocols and some do not allow any by-products. Some of these differences may be sorted out once the USDA sets their standards for "Grass Fed", but I wouldn't count on it.

All other costs in addition to those included in the above formula are charged directly to the customer. This includes mineral, supplements, animal health products, trucking, brand inspection fees, and veterinary expenses.

Weighing Cattle

For all practical purposes contract grazing and grass finishing revolves around animal performance. By that I mean that the customer expects performance which is usually measured by the average daily gain (ADG) of those animals while they were in your care. Providing death loss was kept at a minimum, the customer will usually be satisfied if the cattle have gained well. With that being said, I would like to discuss the method of calculating ADG and its fallability. Of course the equation is rather elementary, you simply divide the weight gain (or loss) by the number of days. However, let me caution you: to determine an ACCURATE ADG the period of measurement must be relatively long. I don't put much stock in ADG figures unless they are done over a period of time in excess of 90-100 days. Weighing cattle over shorter periods of time may give you some indication of performance but I would caution you from making management changes or grazing adjustments based on short term figures. You should also discourage the cattle owner from requiring their cattle to be weighed at short intervals. If they insist you should charge them extra. It will just mean more labor for you and more disruption for the cattle herd, thus reducing gains for every day that you are weighing and handling them. We have done some comparisons that illustrate my points. In the summer of 2006 we weighed a group of cattle and then weighed them again 3 days later. Some of the cattle showed a gain of 90 lbs and some showed a loss of 70-75 pounds along with everything in between that wide range. Of course these steers were not actually gaining 30 lbs/day or losing 25 lbs/day. There is just too much variance in fill weight and hydration levels to accurately measure ADG in the short term. Even if you weigh them at the exact same time of day and in the exact same order, there is still too much room for error. A large animal can easily drink 40-80 pounds of water in just a few minutes. It can also lose a great amount of weight while it is standing around in a corral waiting to be weighed or being sorted and moved around. Even weighing cattle after 30-60 days you could easily show that they are gaining 3 lbs/day or 1 lbs./day when they are actually somewhere in the middle. If you brag to the owner that the cattle are gaining 3 lbs./day they will likely develop very high expectations that you will unlikely be able to meet over the entire length of the contract. If they think they are only gaining a pound a day they may be concerned for no reason and even take the cattle home leaving you with a lot of hay to bale! We base our management decisions on how the cattle did over the entire grazing season which for us is around 180-200 days.

Contracts & Recordkeeping

Not all producers are enthusiastic when it comes to paperwork and I'll have to admit that I fall into that category myself. However, keeping records and writing contracts are essential if you are custom grazing. Your customers are entitled to know what the expectations are and how you are managing their cattle. Communication is the key to building good relationships between yourself and the cattle owner. We encourage the customer to visit our operation and observe what we are doing.

You will need to keep a file on each customer and a grazing log. This should document what pasture and the types of forages the cattle are grazing, You may want to include forage testing results, BRIX readings, and fecal sample analysis. Documentation of when animals are treated, wormed, sprayed, poured, ultrasounded or weighed is essential. Also give notice to the owner and document any death loss or veterinary visits. Keep receipts for all these expenses and provide copies to the customer at billing time. Generally customers are billed on a monthly basis.

The grazing contract is an integral part of the relationship between you and the customer. Obviously the contract should be one that both parties feel comfortable with and protects the interests of both sides. Generally the custom grazier will provide the contract and I highly recommend that. We have had customers that want to use their own contracts and we have declined to use them. Generally they are not in the best interest of the grazier. Keep in mind, you are providing the service and are responsible for the management of the land and your business. It's probably best if you provide your own contract. Also realize that you have no obligation to work with everyone who requests you services. It is best to work with only those that you feel comfortable with. We have turned away people because we didn't think they had realistic expectations or they had unreasonable demands. Some customers may be high maintenance and we prefer to avoid these types. We will also never compromise our integrity or risk our reputation by conforming to someone else's standards that we don't believe in.

Contracts can be simple but should be detailed in specifying the expectations of both parties. Every situation is different so you will not be able to use exactly the same contract with all your customers. Contracts should include dates of grazing period, number of head, weight of cattle, and grazing fees. It should also address issues such as drought provisions, payment schedule, death loss liability, down payments, trucking, veterinary care, treatment of sick animals, worming, fly control, vaccination records, brand inspections, health certificates, animal identification, performance records, written reports, method of weighing, shrink, insurance, supplementation, mineral program, fee adjustments, management protocols and anything else that is discussed and agreed upon.

One last suggestion concerning contract agreements is to require a non refundable down payment and a signed contract well in advance of the grazing season. Otherwise you may find yourself scrambling to find cattle at the last minute. Some cattle owners will verbally commit to any available pasture and then back out if they find something cheaper or closer to home. We've learned some of these lessons the hard way. You don't get paid if you don't have cattle grazing.

Facilities

Livestock handling facilities should be adequate to get the job done but don't need to be elaborate or fancy. They should provide a safe work environment for you and your employees while working, sorting, loading and weighing cattle. Design paddocks and water systems that allow grazing flexibility. Continue to make improvements as time and money allows. We have a limited amount of farm machinery including some hay equipment, a no-till drill, pasture aerator, bale processor, and two tractors. The only hay we put up is from excess grass when pasture growth gets ahead of the cattle. We don't even own a livestock trailer since most farmers in the area have several and are willing to loan us one or haul livestock for us.

Grazing Management

How you manage your grazing land is the key to success. It plays a large part in determining the performance of the animal and the profitability of the farm. It's important to understand that there is not necessarily a high correlation between these objectives. In fact it is generally accepted that these two goals are somewhat antagonistic. Generally speaking the cattle owner is concerned primarily about animal performance and most notably gains. As a land manager, the grazier will best measure profitability on a per acre basis. The question becomes—how should the grazing be managed where both parties will prosper? Likely the best scenario is finding a happy medium. When finishing cattle you likely will not be able to use the highest stocking rate possible and you may not achieve the highest potential in terms of pounds/acre.

We implement management intensive grazing practices on our farm and generally move cattle daily with some groups being moved multiple times each day, depending on the situation. We try to keep grass utilization at reasonably high levels without adversely affecting animal performance to a significant degree. This is a delicate balance but using the simple rule of "taking half and leaving half" of the standing forage, we stay relatively balanced. Another strategy would be to use a leader/follower grazing plan where the leader group has highest priority in terms of achieving the best gains. You could put the animals that are in the "last finishing stage" in the lead group. This can also be done using different classes of the same species or multiple species. Labor and fencing resources will likely dictate the feasibility of this approach. Just keep in mind that grass finished cattle are considered a premium product and many of your decisions will ultimately affect the quality of the end product. And if you expect to receive a premium grazing fee for grass finishing, you need to rise to a higher level of management.

Dry matter intake is crucial to getting good gains. When grass is very lush it will be difficult for cattle to consume enough dry matter to make optimum gains. During these periods we will supplement the cattle with straw or grass hay to help them get the dry matter needed. You can determine this need by forage sampling, manure analysis, or cattle behavior. However it is probably best to make sure that cattle have access to sufficient dry matter if there is any question at all. They will generally eat as much as they need and their own desires are usually the best indicator of dry matter needs. We also observe that moving animals more often will encourage intake and multiple daily moves will optimize animal intake. This however will not negate the need for dry matter supplementation during lush periods.

Other factors that will affect gain are environmental and you have very little control over them. These include altitude, extreme temperatures, humidity, wind, rain, snow and ice. Providing shade and sufficient shelter will help some of these conditions. It is essential that you have backup plans in place for extreme conditions that you may encounter. This might include having a generator in place to pump water when all the power lines go down during an ice storm. In November of 2006 we had the mother of all blizzards that initially lasted for three days with constant winds in the 60-100 mph range along with a foot of snow. It then continued off and on for another week with ground blizzards. We led cattle to natural shelters the day before the storm started and we did not lose any livestock. Others weren't so fortunate. A nearby feedlot lost 2000 head! A fellow rancher in this area lost 60 head of cows and heifers. Another lost 200 head of sheep. Many herds grazing open pivots with no shelter moved 10-20 miles during the storm. Needless to say, animal performance suffered. We figured some of the heavy steers lost well over 100 pounds during this storm.

Disposition of both the animals and the managers will also affect performance. Try to provide a calm environment and get the animals into a consistent grazing routine.

Managing your grass for high sugar content or BRIX readings will also improve the potential for gain on the animals. It is imperative that you are using the right type of grasses/forages and have a comprehensive soil fertility program to accomplish this. You will also need to develop a forage chain that will keep finishing animals on high quality forages.

Cattle will gain more using growth promoters such as implants, ionophores and other feed additives. Generally this is not an accepted practice in the grass finishing industry. It is important that your customer knows this "disadvantage" when it comes to performance if they have traditionally been using such products.

The health of the animals is ultimately your responsibility. You must use common sense and manage the cattle like they are your own. This means detecting problems early and managing to prevent such problems like bloat, parasites, etc. A vaccination requirement should be written into the contract or grazing agreement. Use caution when mixing herds of animals or when running steers and heifers together. We generally try to avoid both of these practices altogether if at all possible. These conditions should be discussed with the cattle owner prior to accepting the cattle.

There are numerous resources you can utilize for input in making management decisions. We find that the best resource is forming a network with other graziers that are in the same business as you are. We have learned a lot from interacting with peers and visiting other operations. We have reciprocated with other graziers in this manner and have hosted tours and field days on our own farm. We have hosted visitors from all across the U.S. as well as several foreign countries. We have attended numerous conferences and seminars. One important lesson that we learned was this: before taking advice from any so called "expert" always ask them how many cattle they have personally finished on grass themselves. By this I mean those that are doing the day to day management of grass finishing. This will quickly weed out the theorists from those that have real world experience that might be useful to your operation.

Landowner Benefits

There are numerous benefits to the landowner when cropland is utilized as pasture when compared to more traditionally raised crops. The reason I point this out is that if you are utilizing rented or leased land to develop a grazing operation, you may need to convince the landlord of these benefits to build a working relationship that is win-win. This can be difficult if you are dealing with a landlord who is firmly entrenched in the traditions of conventional farming. If you own the land yourself, you or your heirs stand to reap the long term rewards from this type of land management. On our own farm we have noticed many benefits leading to improved land quality even in the short term. A few of these include: an increase in water retention, a significant increase in soil organic matter, an increase in biological activity in the soil, and greater wildlife diversity. In addition we have virtually eliminated erosion which is hard to place a value on but it will save you thousands of dollars an acre in the long run. Carbon sequestration is also greater and this can now generate additional income. With a pasture based farming system you will greatly increase your growing season compared to most traditional annual crops. The grass growing season on our farm is typically March through about mid November. With corn it would be May through September although until the corn canopies in late June, you would not be maximizing energy from photosynthesis. Generally speaking these benefits will be amplified when using a management intensive grazing system and it is important for the landowner to understand this as decisions are made to improve fencing and watering systems.

At Fulton Farms we are passionate about grass based farming and we know we are producing a healthier product from livestock raised on pasture. It has also enhanced the quality of our land and improved our quality of life. Our goal is to to continue to build our business and give our three children the opportunity to become involved in the operation if they so desire.

Production Benchmarks for Northeastern Grass-Fed Beef Farms

Emily Steinberg
Pennsylvania State University
University Park, PA

Twenty-six grass fed beef producers were surveyed in Pennsylvania, New York and Maryland. Surveys lasted about an hour and most of them were done at the producers' farms while a few were done by telephone. The surveys were conducted to assess production and develop benchmark production and economic standards for the enterprise. The benefits of this survey data will be to improve productivity and profitability of production and marketing. The farms that were surveyed varied in size from producers who only had 10 acres to producers who had 360 acres of grazing for grass-fed cattle. Production ranged from one grazing animal intended for harvest, to producers who had 75 cattle harvested. Most of the producers reported that total farm cattle sales were from grass-fed beef (Mean = 87.68 %). Most of the producers reported that cattle sales represent 10-25% of the total farm and non-farm income (Mean= 38.5%).

Most of the producers reported that their cattle graze forages with grass/legume combinations (Mean = 60.65%). The majority of the grazed acres are perennial plants (Mean = 66.03 acres). Most of the harvested forage is dry hay (Mean = 53.2%). The bulk of the dry hay is stored in a barn (Mean = 59%). The mean percentage of producers using rotational grazing was 80.52 %. The mean percentage of producers using subdivision fencing was 29.88 %. The paddock size, in acres, per animal is relatively constant throughout the season. Producers tended to rotate the cattle through the paddocks more quickly at certain times. Therefore, the frequency of rotations is very variable depending on the season, the animal, and the forage quality. Producers may benefit from more portable fencing to rotate the paddocks more often to increase stocking rate and maintain forage quality. Most of the producers have permanent water sources (Mean = 63.07%), meaning there is one water source used by all of the animals. Most people raised cattle on the farm (Mean = 61.73 %).

The predominant breed of cattle was Angus (Mean = 50 %) and the other breeds were very variable. The initial weight of the cattle on the farm was extremely variable and this was due to results that indicated cattle remained on pasture from birth to harvest. The majority of the producers are not using preventative vaccines (Mean= 52.2 %) and they do not have any major health problems. Some producers report minor problems with bloat, pink-eye, footrot, and scours. The mean annual health cost per grazed animal was $5.93. The mean length of grazing was extremely long (Min = 307 d; Max = 438 d). This could be improved with better genetics and forage maintenance. The mean weight at harvest was 1087 pounds. The mean age at harvest was 22 months with a minimum age of 14 months and a maximum age of 28 months. There may be a need to reduce harvest age with improved genetics and forage quality maintenance to reduce production cost.

All the producers used whole carcass aging with the exception of one producer who used wet-aging in vacuum packaging. Most of the producers sold retail cuts only (Mean=55.2 %). Most of the producers used vacuum packaging (Mean = 62.8 %). Not many producers used post-harvest interventions (other than aging) nor did they have information about them. According to the producers, pricing is determined by production cost, what the market can bear, local competitors, retail prices, and available niche markets. The best way to advertise was by word of mouth. Labeling is extremely variable and few people have a certified organic label because the procedure is “tedious and expensive”. The reasons they produce grass-fed beef for market is because they like it, they do not mind the work and they want more family time. Some of the production problems reported were lack of carcass predictability, the quality of processors, misinformed consumers and processors, and local customer bias against grass-fed beef. The results of the survey indicate some specific unrealized production and marketing opportunities for grass-fed beef producers in the Northeast.

Survey Instrument

Grass-fed Beef Production In 2006

The term grass-fed beef is here used as a general term for cattle that may include pasture-raised or other generic term for cattle grazed and sold.

1. What is the total acreage of the farm being used for beef production?

   a. total acres of grazing
      Mean: 78.64 acres
      Minimum: 10 acres
      Maximum: 360 acres
   b. total acres of other crops not grazed
      Mean: 37.48 acres
      Minimum: 0 acres
      Maximum: 190 acres
   c. total acres in grass-fed beef intended for slaughter
      Mean: 69.8 acres
      Minimum: 10 acres
      Maximum: 550 acres
   d. total acres in certified organic production
      Mean: 13.46 acres
      Minimum: 0 acres
      Maximum: 185 acres
2. What is the total number of cattle on the farm on July 1, 2006?
   - number of cow-calf units
     Mean: 20.58 units
     Minimum: 0 units
     Maximum: 70 units
   - number of grazing cattle intended for harvest
     Mean: 21.92 cattle
     Minimum: 1 cattle
     Maximum: 75 cattle

The remainder of the questions pertain to grass-fed beef production intended for harvest.

3. Total receipts from the marketing of grass-fed cattle on the farm
   % of the **total** farm cattle sales from grass-fed beef
   Mean: 87.68%
   Minimum: 10
   Maximum: 100

- Cattle sales represent a) less than 10% of total farm and non-farm income; b) 10%-25% of total farm and non-farm income; c) 25%-50% of total farm and non-farm income; d) 50%-75% of total farm and non-farm income; e) 75% -100% of total farm and non-farm income.
  - ***38.5% of the farmers reported that cattle sales represent 10-25% of total farm and non-farm income.***

4. Forages
   - % of acres grazed by cattle in

     • %"native grasses"
     Mean: 17.96
     Minimum: 0
     Maximum: 100
     • % single perennial grass
     Mean: 0
     Minimum: 0
     Maximum: 0
     • % mixed grasses
     Mean: 16.32
     Minimum: 0
     Maximum: 100
     • % grass/legume combinations
     Mean: 60.65
     Minimum: 0
     Maximum: 100
     • % legumes only
     Mean: 0.385
     Minimum: 0
     Maximum: 10
     • % annual grasses
     Mean: 4.31
     Minimum: 0
     Maximum: 30
     • % brassicas or forbs
     Mean: 1
     Minimum: 0
     Maximum: 10
   - Predominant grazed perennial grass is a) orchardgrass; b) smooth bromegrass; c) fescue; d) perennial ryegrass; e) bluegrass; f) other
     - ***53.8% of the producers reported that the predominant grazed perennial grass was orchardgrass***

- Number of grazed acres by cattle that are annual plants
  Mean: 3.21 grazed acres
  Minimum: 0 acres
  Maximum: 25 acres
- Number of grazed acres by cattle that are perennial plants
  Mean: 66.03 grazed acres
  Minimum: 0 acres
  Maximum: 225 acres
- Number acres grazed by cattle of intentional forage species mix
  - grass+ legume
    Mean: 40.74 acres
    Minimum: 0 acres
    Maximum 225 acres
  - grass mixture
    Mean: 17.81 acres
    Minimum: 0 acres
    Maximum: 360 acres
  - legume mixture
    Mean: 5.31 acres
    Minimum: 0 acres
    Maximum: 130 acres
  - grass+brassica
    Mean: 1.88 acres
    Minimum: 0 acres
    Maximum: 40 acres
  - other
    Mean: 1.26 acres
    Minimum: 0 acres
    Maximum: 19 acres
- acreage of predominantly alfalfa pasture grazed by cattle
  Mean: 0.69 acres
  Minimum: 0 acres
  Maximum: 8 acres

5. Harvesting

a. % of harvested forage as dry hay
Mean: 53.2
Minimum: 0
Maximum: 100

b. % of harvested forage as balage

Mean: 38.708
Minimum: 0
Maximum: 100

c. Number of tons of harvested forage as haylage or silage in a tower, bunk, or bag silo

Mean: 17.83
Minimum: 0
Maximum: 250

- % of dry hay stored in a barn
  Mean: 59
  Minimum: 0
  Maximum: 100
- % of dry hay stored outside
  Mean: 25
  Minimum: 0
  Maximum: 100
- Number of acres mowed with no mechanical harvest (bush hogging pasture with possible multiple trips over the same acreage)
  Mean: 56.68 acres
  Minimum: 0
  Maximum: 400

6. Pasture and Forage Maintenance

- Fertility applied per acre of grazed forage or total cost of fertilizers for pastures used for beef intended for harvest
  - manure in tons
    Mean: 364 tons
    Minimum: 0 tons
    Maximum: 7,500 tons
  - commercial fertilizer tonnage and cost
    Mean Cost: $553.69
    Range of cost: $5,000
  - estimate of pounds of nitrogen per acre from commercial fertilizer
    Mean nitrogen: 12.14 pounds
    Minimum: 0
    Maximum: 100

- herbicides applied and cost
  Mean cost: $70
  Minimum: $0
  Maximum: $1,500

Four producers said that they used herbicides.

5. Facilities

- Approximate length of permanent fencing for pastures used for beef intended for harvest (perimeter and/or interior): <1/5 mile; 1mi; 1.5 mile; 2 mi; 2.5 mi; ___ mi.
  Mean length: 3.57 miles
  Minimum: 0.5 miles
  Maximum: 11.5 miles
- What was the initial cost?
  Mean of initial cost: $12,406.25
  Minimum: 0
  Maximum: 50,000
- Are these acres used by animals not beef or beef not intended for harvest? What percentage of the grazing time will other animals use the pasture?
  Mean %: 44.072
  Minimum %: 0
  Maximum %: 100
- % of grazed acres by grass-fed beef cattle in subdivision fencing
  Mean %: 29.88
  Minimum %: 0
  Maximum %: 100
- % of grazed acres by grass-fed beef cattle in rotational grazing
  Mean %: 80.52
  - ***Farmers generally kept the paddock size constant throughout the season; they rotated the cattle through the pastures more quickly during lower growth periods.***
- usual frequency of rotations
  Mean: 6.04 days
  Minimum: 0
  Maximum: 42
  - ***Almost all the producers reported the frequency of rotations was extremely variable. Longer rotations were reported during good forage growth and when the grass is not growing well because of drought they will rotate more quickly.***

- Water systems
  - % of water sources in permanent sites (the cattle on the site will all drink from the same water source)
    Mean %: 63.07

Minimum %: 0
Maximum %: 100

- % of water sources in portable sites (the cattle will drink from a different source in each paddock)
  Mean %: 36.54
  Minimum %: 0
  Maximum %: 100

- cattle handling chutes and corrals
  - approx. age (years)
    Mean age: 15.35
    Minimum age: 0
    Maximum age: 62
  - initial cost
    Mean cost: $2,548
    Minimum cost: $0
    Maximum cost: $10,000

6. Equipment

- Tractors: age and current value
  Mean age: 23.7 yr
  Minimum age: .08 yr
  Maximum age: 51 yr
  Mean current value: $24,833.33
  Minimum value: 0
  Maximum value: $68,000
- Hay Mowers/conditioners : age and current value
  Mean of age: 16.8 yr
  Minimum age: 2 yr
  Maximum age: 35 yr
  Mean of current value: $3,468
  Minimum value: 0
  Maximum value: $25,000
- Hay balers: age and current value
  Mean of age: 20.3 yr
  Minimum age: 1 yr
  Maximum age: 50 yr
  Mean of current value: $4,377.08
  Minimum value: 0
  Maximum value: $23,000
- Hay wrappers : age and current value
  Mean of age: 7.3 yr
  Minimum age: 2 yr
  Maximum age: 21 yr

Mean of current value: $2,660
Minimum value: 0
Maximum value: $20,000

- Rotary mowers: age and current value
  Mean of age: 13.9 yr
  Minimum age: 3 yr
  Maximum age: 30 yr
  Mean of current value: $2,804.17
  Minimum value: 0
  Maximum value: $40,000
- Tillage equipment: age and current value
  Mean of age: 15.7 yr
  Minimum age: 2 yr
  Maximum age: 40 yr
  Mean of current value: $975
  Minimum value: 0
  Maximum value: $7,000

- Trucks: % of farm use for cattle, age, and current value
  Mean % of farm use for cattle: 48%
  Minimum % of farm use for cattle: 0
  Maximum % of farm use for cattle: 100
  Mean age: 12.9 yr
  Minimum age: 4 yr
  Maximum age: 29 yr
  Mean current value: $10,404.35
  Minimum value: 0
  Maximum value: $37,000
- Stock trailers: % of farm use for cattle, age, and current value
  Mean % of farm use for cattle: 81%
  Minimum % of farm use for cattle: 0
  Maximum % of farm use for cattle: 50
  Mean of age: 9.1 yr
  Minimum age: 2 yr
  Maximum age: 20 yrs
  Mean of current value: $1,383.33
  Minimum value: 0
  Maximum value: $9,000
- Other equipment: age and current value
  Mean age: 11.0 yr
  Minimum age: 2 yrs
  Maximum age: 30 yrs
  Mean current value: $9,650

Minimum value: 0
Maximum value: $46,100

7. Cattle

- # and % of total grass-fed beef cattle intended for harvest raised on the farm
  Mean number: 25.6head
  Minimum number: 0
  Maximum number: 250
  Mean %: 61.73
  Minimum %: 0
  Maximum %: 100
- # and % of cattle purchased for resale as grass-fed beef intended for harvest
  Mean number: 6.5 head
  Minimum number: 0
  Maximum number: 42
  Mean %: 38.27
  Minimum %: 0
  Maximum %: 100
- Predominant breed of cattle
  - Angus: 50%
  - Hereford: 15.38%
  - Limousin: 7.69%
  - Devon: 7.69%
  - Red angus: 3.85%
  - American Lowline: 3.85%
  - Galloway-British White Cross: 3.85%
  - Scottish Highland: 3.85%
  - Belted Galloway: 3.85%

- Initial weight of cattle grazed and intended for harvest (at turnout)
  Mean: 369.1 lbs.
  Minimum: 55
  Maximum: 850
  The reason for this large range is because some producers reported those raised on the farm were placed on pasture at calving.

  Health program
  - IBR, BVD, PI3, BRSV, H. somnus, other respiratory vaccines used
    - ***52.2% of the producers surveyed are not vaccinating***
  - Deworming cost

Mean cost: $3.92
Minimum cost: 0
Maximum cost: 15

- Primary health concerns:
    - bloat
    - respiratory disease
    - scours
    - coccidiosis
    - grass tetany
    - SE deficiencies
    - Footrot
    - Others
    - ***Most of the producers reported that health was not a major concern.***
    - ***Some that were noted: bloat, pinkeye, footroot, and scours***

- annual health cost per grazed animal intended as beef
  Mean: $5.93
  Minimum: 0
  Maximum: 20

- % heifers, % steers, % bulls grazed for harvest
    - ***No bulls were grazed for harvest; heifer numbers fluctuated due to the need for replacement females.***
- Implants used (yes,no)
    - ***No implants were used***
- Purchased feeds: amount and cost
    - Minerals
      Mean cost: $452.14
        - ***Minerals were the primary purchased feed***
    - Grain by-products
      Mean cost: $15.38
      Minimum: 0
      Maximum: 400
        - ***One producer used grain products***
    - Grain
      Mean cost: $137
      Minimum: 0
      Maximum: 2,000
      Six producers used grain
    - Food by-products

- ***Food by-products were not used***
- Subtherapeutic antibiotics used (such as Rumensin, Bovatec, or Tylan; yes,no)
    - ***Subtherapeutic antibiotics were not used***
- Wintering programs (non-forage growth phase-**usually November through April)**
    - dry hay %
      Mean%: 59.472
      Minimum %: 0
      Maximum %: 100
    - balage %
      Mean %: 40.758
      Minimum %: 0
      Maximum %: 100
    - grazing stockpiled forage (the number of days cattle intended for harvest graze with no other feed available from November through April
      Mean: 50.9 days
      Minimum: 0
      Maximum: 214
    - Haylage or silage tons
      Mean: 20.65 tons
      Minimum: 0
      Maximum: 250
    - grains
        - corn % or pounds used
          Mean %: 5.625
          Minimum %: 0
          Maximum %: 100
        - byproducts % or pounds used
          Mean %: 0
          Minimum %: 0
          Maximum %: 0
        - small grains % or pounds used
          Mean %: 0
          Minimum %: 0
          Maximum %: 0
        - commercial feeds % or pounds used
          Mean %: 35.42
          Minimum: 0
          Maximum: 800

- % of cattle raised from AI matings
  Mean %: 10.3
  Minimum %: 0
  Maximum %: 100
  Five producers used AI matings
- Major selection tools used for production of cattle grazed for harvest as beef
  - breed
    Mean %: 46.15

  - frame size
    Mean %: 38.5
  - carcass EPDs
    Mean %: 0
  - growth EPDs
    Mean %: 0
  - maternal EPDs
    Mean %: 3.85
  - What is the most important selection tool?
    - ***Most producers reported that breed and frame size were most important.***
    - ***Other reported an expected balance of traits.***

- Average number of days cattle graze between weaning and harvest
  - shortest expected grazing period
    Mean: 307.1 days
    Minimum: 45
    Maximum: 730
  - longest expected grazing period
    Mean: 437.6 days
    Minimum: 90
    Maximum: 870
  - ***Implies that the producers are wintering cattle twice***
  - ***There is a substantial cost added to production***
  - ***Genetics may be a good tool to speed up production***

8. Cattle Harvest
   - the major factor determining harvest date: a) animal weight b) animal age; c) fat thickness; d) days grazed; e) available processor; f) calendar date; g) other
     - ***Fat thickness with 26.9% of the producers***
     - ***Very variable***
   - average live weight at harvest and weight range

Mean of average live weight: 1087.3 pounds
Minimum: 700
Maximum: 1500

- average age at harvest and age range
  Mean of average age at harvest: 21.8 months
  Minimum age: 14 months
  Maximum: age: 28 months
- ***A reflection of grazing period: some cost reductions may be needed.***
- number harvested at each harvest date and range
  Mean: 3.5 cattle
  Minimum: 1
  Maximum: 11

9. Processing
   - distance to processor
     Mean: 33.1 miles
     Minimum: 3
     Maximum: 100
   - transportation time to processor
     Mean: 50.19 minutes
     Minimum: 5
     Maximum: 120
   - average time interval between farm loadout and knockdown
     Mean: 12.5 hours
     Minimum: 0 hours
     Maximum: 45 hours
   - number of processors available to use within a 100-mile radius
     Mean: 7.4
     Minimum: 1
     Maximum: 30

   - carcass aging
     - average length of time of aging
       Mean: 15.6 days
       Minimum: 1.5 days
       Maximum: 30 days
     - % whole carcass aging
       Mean %: 100
       Minimum %: 100
       Maximum %: 100

% wet aging in vacuum packaging
Mean %: 3.85
Minimum %: 0
Maximum %: 100

- ***Only one producer did wet aging in vacuum packaging***

- who determines aging time
  *producer
  *processor
  * customer
  - ***Aging time is usually determined by the producer***

- fabrication of carcass
  - % wholesale cuts only (whole chuck, rib, loin or round)
    Mean %: 37.1
    Minimum %: 0
    Maximum %: 100

  - % retail cuts only
    Mean %: 55.2
    Minimum %: 0
    Maximum %: 100
  - % mix of wholesale and retail cuts
    Mean %: 7.7
    Minimum %: 0
    Maximum %: 100
  - Is the product frozen or fresh at pickup from the processor
    - ***Almost all of the producers' products were frozen at pick-up from the process.***
    - ***Only one producer's products were fresh at pick-up from the processor***
  - Is the product frozen or fresh at the point of sale
    - ***Almost all of the producers' products were frozen at point of sale***
    - ***Only three producers' products were fresh at point of sale***
  - who determines cutting process
    - processor
    - customer
    - producer
    - ***The cutting process is generally determined by the processor and customer***
  - type of packaging

% freezer wrap
Mean %: 32.35
Minimum %: 0
Maximum %: 100

- % vacuum package
  Mean %: 62.81
  Minimum %: 0
  Maximum %: 100
- % retail case visual packaging
  Mean %: 3.85
  Minimum %: 0
  Maximum %: 100
- % modified atmospheric packaging
  Mean %: 0
  Minimum %: 0
  Maximum %: 0

- process interventions
  - electro-stimulation
  - ***No one used this and the majority of the producers did not know what it was***
  - % of carcasses graded for USDA quality grades
    Mean %: 15.58
    Minimum %: 0
    Maximum %: 100
  - ***Four producers had their carcasses graded***
  - % of carcasses with fat profile analysis
    Mean %: 3.7
    Minimum %: 0
    Maximum %: 100
  - ***One producer used the fat profile analysis***
  - feeding carcass enhancements such as Vitamin E
  - ***No producers used carcass enhancements***

10. Marketing
    - pricing
      - % sold by the pound on live weight and average price
        Mean price/lb: $2.14
        Minimum price/lb: 1.16
        Maximum price/lb 5.00
        Mean %: 8.9
        Minimum %: 0
        Maximum %: 100

- % sold by the pound on hot carcass weight and average price
  Mean price/lb:$2.49
  Minimum price/lb: 1.60
  Maximum price/lb: 4.25
  Mean %: 53.6
  Minimum %: 0
  Maximum %: 100
- % sold as individual retail cuts and average price
  Mean price/lb: $5.55
  Minimum price/lb: 2.50
  Maximum price/lb: 7.50
  Mean %: 28.9
  Minimum %: 0
  Maximum %: 100
- % sold as package of cuts and average price and weight
  Mean price/lb: $3.63
  Minimum price/lb: 2.25
  Maximum price/lb: 5.00
  Mean %: 8.6
  Minimum %: 0
  Maximum %: 100

- Most important price determination
  - local markets for live cattle
  - "yellow sheet" or national fat steer market
  - cost plus % added value
  - other
  - ***What it costs to produce***
  - ***What market can bear***
  - ***Local competitors***
  - ***Retail prices***
  - ***Niche Market***
- advertisement: score importance from 1 to 9 with 9 being highly important and 1= not important at all or not used
  - word of mouth
    Mean: 8.5
    Minimum Score: 4
    Maximum Score: 9
  - printed fliers are distributed and cost
    Mean score: 3.33
    Minimum Score: 1

Maximum Score: 9
Mean price/yr: $113.10
Minimum price/yr: 0
Maximum price/yr: 600

- newspaper and magazine ads and cost
  Mean score: 2.18
  Minimum Score: 1
  Maximum Score: 9
  Mean price/yr: $315.83
  Minimum price/yr: 30
  Maximum price/yr: 1,000
- web site and cost
  Mean score: 2.54
  Minimum Score: 1
  Maximum Score: 8
  Mean cost/yr: $658.33
  Minimum cost/yr: 0
  Maximum cost/yr: 4,500
- other (TV, radio, farm tours, etc.) and cost
  - ***Mostly farm tours (Cost varied from $0-$500)***
  - ***One producer used a power point presentation as a learning tool (Cost ~$75)***

- customer source
  - % freezer beef
    Mean %: 80.1
    Minimum %: 0
    Maximum %: 100
  - % conventional markets and sale barns
    Mean %: 0.48
    Minimum %: 0
    Maximum %: 10
  - % farmer-owned retail outlet
    Mean %: 10.95
    Minimum %: 0
    Maximum %: 90
  - % non-owned retail outlet (grocery store, etc.)
    Mean %: 1.43
    Minimum %: 0
    Maximum %: 30
  - % restaurants
    Mean %: 7.40
    Minimum %: 0
    Maximum %: 100

- % mail order
  Mean %: 0
  Minimum %: 0
  Maximum %: 0
  - ***Majority of the producers have freezer beef***
  - ***Six producers have a store***
  - ***No producers are doing mail order***
  - ***Fewer producers are marketing to sale barns, grocery stores and restaurants***
- packaging
  - % farm label used
    Mean %: 24.92
    Minimum %: 0
    Maximum %: 100
  - % BQA or process label used
    Mean %: 6.8
    Minimum %: 0
    Maximum %: 100
  - % natural label used
    Mean %: 7.69
    Minimum %: 0
    Maximum %: 100
  - % certified organic label used
    Mean %: 0.96
    Minimum %: 0
    Maximum %: 25
  - % No labeling used
    Mean %: 14.35
    Minimum %: 0
    Maximum %: 100
  - % Other label used and name
    - ***Cut ID and weight***

11. Producer information

- average age of the manager(s) of the grass-fed production farm
  Mean: 48.1 yr
  Minimum: 25
  Maximum: 74
- female or male
  - ***73% male***
  - ***Married couples***
- education

- less than high school
  7.69%
- high school graduate
  11.54%
- college or technical school graduate
  26.92%
- professional or graduate school
  53.85%

- Raised on a farm (yes,no)
  - ***57.69% of the producers were raised on the farm***
- Number of years producing and marketing grass-fed beef for harvest
  Mean: 7.0 yr
  Minimum: 1
  Maximum: 31
- Business debt for assets dedicated to grass-fed beef for harvest
  - debt on cattle: none; **80.77%**
    <$1000; **0%**
    $1000-$5000; **3.85%**
    $5000-$10,000; **3.85%**
    >$10,000 **7.69%**

  - debt for equipment: none; **61.54%**
    <$1000; **0%**
    $1000-$5000; **11.54%**
    $5000-$10,000; **15.38%**
    $10,000-$20,000; **7.69%**
    >$20,000 **3.85%**

  - debt on land: none; **61.54%**
    <$5000; **3.85%**
    $5000-$10000; **0%**
    $10000-$20,000; **0%**
    $20,000-$50,000;**7.69%**
    $50,000-$100,000; **11.54%**
    >$100,000 **15.38%**
    - ***Mean debt on land was 5,000-10,000 to 10,000-20,000***
- Estimated asset value of the farm attributed to the grass-fed cattle operation (what could the farm be sold for today)
  Mean: $783,833.33
  Minimum: 65,000
  Maximum: 4,000,000
- Annual cost of hired labor on the farm
  Mean: $11.47

Minimum: 200
Maximum: 40,000

- % of annual work from hired labor
  Mean %: 14
  Minimum %: 0
  Maximum %: 80
- Average number of hours per day dedicated to grass-fed beef production by manager and/or hired labor.
  Mean: 3.45 hours
  Minimum: 10 minutes
  Maximum: 8 hours

Please score the following items 1-9 you perceive as the reasons you produce grass-fed beef for sale with 9= very important reason and 1=not important at all to me:

a. life-style
   Mean: 7.38
   Minimum Score: 1
   Maximum Score: 9
b. profit
   Mean: 6.19
   Minimum Score: 1
   Maximum Score: 9
c. environmental concerns
   Mean: 7.44
   Minimum Score: 1
   Maximum Score: 9
d. human health issues
   Mean: 7.5
   Minimum Score: 1
   Maximum Score: 9
e. animal welfare concerns
   Mean: 7.52
   Minimum Score: 5
   Maximum Score: 9
f. available markets
   Mean: 6.92
   Minimum Score: 1
   Maximum Score: 9
g. labor available
   Mean: 3.69
   Minimum Score: 1
   Maximum Score: 9
h. facilities and equipment available

Mean: 5.58
Minimum Score: 1
Maximum Score: 9

i. vegetative control on the farm
Mean: 6.08
Minimum Score: 1
Maximum Score: 9

j. as part of a crop rotation
Mean: 3.31
Minimum Score: 1
Maximum Score: 9

k. other (name)

- ***Money***
- ***Workaholic***
- ***Just like to do it***

Please rank the following you perceive as problems you encounter in producing and marketing grass-fed beef with 9= very important problem and 1=not important at all to me:

a. life-style change
Mean: 2.08
Minimum Score: 1
Maximum Score: 9

b. identification of new customers
Mean: 3.96
Minimum Score: 1
Maximum Score: 9

c. lack of cattle production information
Mean: 2.81
Minimum Score: 1
Maximum Score: 5

d. availability of processors
Mean: 4.96
Minimum Score: 1
Maximum Score: 9

e. animal health
Mean: 2.31
Minimum Score: 1
Maximum Score: 9

f. consistency of meat products
Mean: 4.81
Minimum Score: 1

Maximum Score: 9

g. labeling and packaging issues
   Mean: 3.08
   Minimum Score: 1
   Maximum Score:7
h. time commitment for selling and promoting products
   Mean: 4.31
   Minimum Score: 1
   Maximum Score: 9
i. availability of cattle
   Mean: 3.65
   Minimum Score: 1
   Maximum Score: 9
j. lack of forage production information
   Mean: 2.5
   Minimum Score: 1
   Maximum Score: 9
k. returns from customers/critical customers
   Mean: 2.23
   Minimum Score: 1
   Maximum Score: 9
l. marketing the whole carcass
   Mean: 2.96
   Minimum Score: 1
   Maximum Score: 9
m. identification of market outlets
   Mean: 4.58
   Minimum Score: 1
   Maximum Score: 9
n. lack of capital
   Mean: 3.77
   Minimum Score: 1
   Maximum Score: 9
o. other and name

- ***Predictability***
- ***Procedure for becoming organic***
- ***Quality of processors***
- ***Getting water sources in every paddock***
- ***Marginal rate of return on investment***
- ***Marketing to new customers***
- ***Misinformed consumers and producers***
- ***Lack of information about proper procedure for storing forage over winter months***

- ***Local bias about grass-fed beef***
- ***Getting satisfactory returns in the shortest amount of time (genetics)***

How to Prevent Dark Cutting Beef and Improve Meat Quality

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Dark cutting beef is a severe beef quality defect that downgrades meat. Consumers do not like dark cutting beef because it is darker and drier than normal. It does not have the attractive red color. Another problem with dark cutting beef is that it has a much shorter shelf life in the retailer's meat case. This is a serious problem because a grocery store may have to throw out more beef because it goes bad more quickly.

Beef becomes dark when a combination of stressors use up the muscle energy stores. Energy that fuels the muscles is stored as glycogen. When the glycogen stores run out, the pH of the beef rises and the beef becomes dark. It is like a car running out of gas; the beef does not turn dark until all of the glycogen is gone. This explanation is somewhat over simplified but it provides producers with an easy way to predict potential problems with dark cutters. Like a car, how far it will run before the gas runs out depends on two factors, 1) the amount of gas that was in the tank to start with and 2) factors such as speeding and stamping on the gas pedal that burns fuel at a faster rate. The amount of glycogen that is stored in the muscle, and the rate that the glycogen is used up when the animal is stressed determines whether or not a particular animal will cut dark. The avoid a dark cutter, the animal must get through the stunner at the processing plant before the glycogen runs out.

The most critical time in an animal's life from a dark cutter standpoint, is the last three of four days prior to slaughter. A single stressor usually does not cause a dark cutter, but several stressors combined can make the glycogen run out. Some examples of stressors that increase the percentage dark cutters are:

Stressors that Contribute to Dark Cutters

1. Rough handling and electric prods.
2. Mixing strange animals, fighting, and mounting.
3. Storms or severe temperature fluctuations within four days of slaughter. Hot days and cold nights in the fall tend to increase dark cutters.
4. Spending the night at the processing plant.
5. Long transport time of over 8 hours.
6. A painful health problem w hich can also cause tough meat.
7. Cattle with a nervous, excitable temperament that startle easily may be more prone to dark cutting. The really crazy cattle are the more likely to be dark cutters.

The seven factors listed above often interact with production factors that cause the animal to have low levels of muscle glycogen before the process of transport and handling at the processing plant begins. An animal that starts out with a low level of glycogen is more likely to become a dark cutter after a storm than an animal that started out with a higher level. To avoid a dark cutter, the animal must get to the stunner before the muscle fuel runs out.

Prediction Factors That May be Associated with Increasing the Susceptibility to Dark Cutting and Reduced Marbling in Beef.

1. Over use of hormone implants for maximum growth.
2. Breeding for rapid growth and leanness. Very lean animals with low levels of marbling (intermuscular fat) may be more prone to dark cutting. Lean animals may have tougher, drier meat.
3. Beta-agonist supplements such as ractopamine which increases lean muscle mass, especially at higher doses.
4. Animals that have been fed low energy, poor quality feed. High quality feeds help to raise the levels of glycogen.
5. Animals subjected to severe weather conditions.

In beef production, the quality of the meat and the quantity of beef are two opposing goals. When breeding programs and supplements are used to obtain maximum rapid growth with a large amount of lean muscle, meat quality may be worse. The beef may be tough and have a low level of marbling. The recent 2005 Beef Quality Audit indicated that marbling in beef has declined. This is bad because the consumer is more likely to get a steak they do not like.

Steps to Reduce Dark Cutters

1. Do not allow the cattle to spend the night at the processing plant. Ideally cattle should reach the stunner within 2 hours after arrival. A short period of 30 minutes to settle down between unloading and stunning is often advisable.
2.

3. Low stress handling methods are essential. The trailer, ramps, and chute at the plant should all have non-slip flooring. Cattle should move through the chute easily. If they balk or back up at the stun box entrance, the chute may need more lighting or the addition of solid sides.
4. On the farm, cattle need to be habituated to strange people walking among them. This will help reduce stress during handling and transport. Cattle must be accustomed to being handled by people on foot before arrival at the plant.
5. Do not mix strange cattle within 7 to 10 days prior to slaughter. Fighting and mounting use up muscle glycogen.

At 4-H and FFA shows, steers must not be mixed in a pen at the fairgrounds prior to shipment to the processing plant. This can cause high levels of dark cutting. After the sale, each steer should return to its individual tie stall. On the day of slaughter, the steers can be grouped on the truck and taken to the plant. They should be slaughtered within one or two hours after arrival. Steers that fight or mount after unloading at the plant should be processed first before muscle exertion cause them to run out of glycogen. If the steers were mixed at the fairgrounds overnight, it will take 10 days of feeding to replenish their glycogen levels. Steers that are not processed promptly after the fair should be group penned for 10 days and fed. This will provide enough time to form a new dominance hierarchy and recover.

6. Reduce the use of growth promoting hormone implants and supplements. Research done by John Scanga at CSU showed that excessive doses of

7. estrogen type implants increase susceptibility to dark cutters in heifers and excessive use of synthetic male hormone implants may increase dark cutters in steers. Implant and supplement programs designed for maximum growth may reduce beef quality.
8. Select cattle with a calm temperament. Flighty, excitable cattle that become agitated in the squeeze chute or run out quickly, may be more prone to have dark cutters or tough meat. It is recommended to cull the really crazy cattle instead of selecting for the absolutely most calm cattle. Selecting for the most calm animals may cause a reduction in other desirable traits such as mothering or foraging ability. Never over select for a single trait. Producers should also avoid selecting for excessive amounts of lean muscle. For grassfed cattle, the older genetic lines of the British breeds are often best because they marble more easily. Lean cattle that produce quality beef on a grain diet may produce poor grassfed beef that is dry and tough. For good grassfed beef, old fashioned British cattle with the shorter blocky body type are recommended.

Conclusions

No single one thing causes a dark cutter. A variety of stressors can deplete the animal's glycogen stores. A single stressor such as severe weather may not cause dark cutters unless it is combined with another factor. Since dark cutters occur, like a car running out gas, epidemics where large numbers of cattle cut dark may happen. One group of cattle may have 0% dark cutters and another group may have 15%. The group that had 15% may have had bad weather combined with low energy feed and rough handling. The factors interact in a complex manner and determine if the glycogen Hill run out.

Internal Parasites of Cattle: Current Control Programs, Present and Future Problems, and Alternative Options

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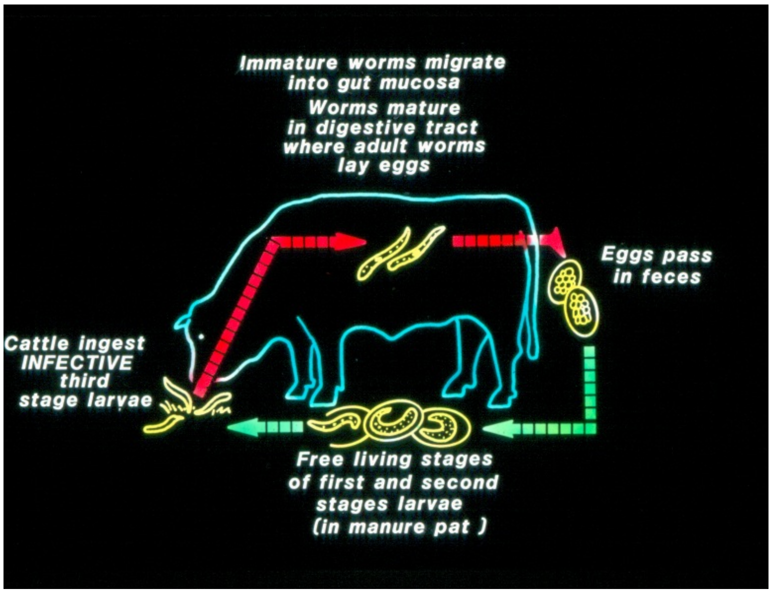

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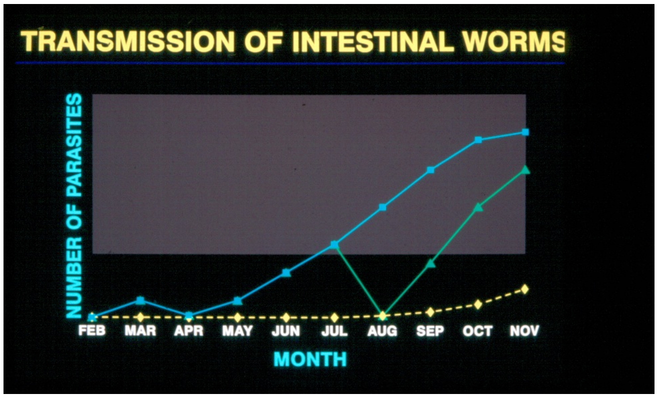
Parasitic nematodes of cattle are a significant constraint on the efficient production of meat and dairy products in any cattle management system where forage is an important nutritional component for at least some portion of the management program. These parasites and their hosts have co-evolved over millenia to a point where optimal conditions for parasite transmission closely mimic those for optimal forage growth and productivity. Although the life cycle of the parasites is relatively simple, the rate of parasite transmission is affected by both environmental conditions and management decisions. The dominant environmental factors influencing parasite transmission are moisture and temperature, with moisture being the more important component. Management factors that exert the greatest influence are grazing intensity and the presence of susceptible individuals in the grazing groups.

As indicated earlier, parasites and their hosts have co-evolved over millions of years. Under natural conditions with extensive grazing opportunities the overall effects of the parasites would be minimal because the host immune system of most animals actively suppresses parasite transmission. Unfortunately, such conditions are not practical for a profitable beef or dairy enterprise. Instead we ask for maximal production on limited resources.
The subsequent effects of the parasites on animal productivity and well-being are seen both directly and indirectly. Direct effects are in the form of : decreased intake of nutrients; poor utilization of nutrients after ingestion; and physiological responses counter to growth and productivity. Indirect effects are in the form of a potential

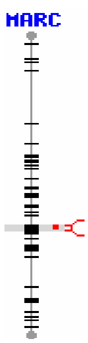


decreased ability to mount effect immune responses to other infectious challenges or vaccinations. The discovery approximately 30 years ago of anthelmintics that exhibited very broad ranges of efficacy while at the same time very low levels of toxicity greatly changed how cattle were managed in the US. Over the last 30 years, producers have been able to intensify their production systems and maximize productivity by using these drugs as preventive agents rather than as therapeutic agents. As illustrated in the accompanying figure, drugs are administered early in the transmission season in an attempt to retard the build-up of parasites on pastures rather than later in the season after parasite numbers have already increased. Treatment later in the season while clearing the animals of existing worms results in a diminished effect on productivity because the cattle are immediately subjected to exposure by large numbers of parasites already on the pastures. Unfortunately, this concept of "strategic deworming" if often expanded in an attempt to rid the pastures of parasites completely. This extension and expansion of the concept of control of parasite numbers to that of eradication of the parasites is a result of several factors including, producer awareness of the subtle effects of the parasites, a movement to more intensive grazing programs, the formulation of more potent and prolonged drug actions, and the availability of cheaper generic compounds. The result has been an increase in the overall use of anthelmintics and a subsequent increase of the selective pressure for drug resistance,

Over the past 2-3 years it has become evident that the modern anthelmintics upon which the American cattle industry has come to rely have begun to show diminished efficacy. There are increasing reports that treatment with either the avermectins or the benzimidoles failed to result in a greater than 90 % reduction in fecal egg counts, or that after such treatment significant numbers of parasites remain in the abomasum and/or small intestine. To date this anthelmintic resistance has been only documented in the genera *Haemonchus* and *Cooperia* and has not yet been seen in the important pathogen *Ostertagia ostertagi*. While it is fortunate that *Ostertagia* has not yet demonstrated drug resistance in the US, the fact remains that the resistant species can and are causing significant production losses. The resistant forms encountered to date appear to be sensitive to levamisole, but this older drug is also least efficacious against *Ostertagia* indicating that programs based upon this drug alone will not be sustainable, and in the short term, the use of multiple drug classes exhibiting different modes of action may be required to control nematodes in intensive management systems or as therapeutic treatments for cattle entering feedyards. Such decisions will require additional information concerning: 1) the patterns of drug resistance seen in the various nematode species, 2) the extent of the resistance problem not only geographically but also characterized by management system, and 3) the effects of removal of drug sensitive populations on the colonization of the bovine gut by non-sensitive species. This information will be critical for the development of anthelmintic treatment programs that will continue to adequately control parasitism and insure the economic viability of the American cattle industry.

A

While alternative anthelmintic programs are necessary in the short-term, the long-term goal should be to identify integrated management programs that use a variety of management options to minimize the impact of the parasites. There will likely not be a single treatment protocol but rather a combination of approaches each of which exerts different kinds of selective pressure on the parasite populations. These options will include, management protocols that provide means to lessen parasite availability during key points in parasite transmission cycles, the use of natural compounds and forages that have deleterious effects on the parasites, the potential use of biocontrol agents, and use of the host immune system to limit parasite establishment and fecundity. At this point perhaps the most promising avenue is using the diversity of the cattle genome to reduce parasite transmission. In a given herd most animals exhibit relatively low levels of parasite egg shedding, and only a small percentage of animals account for most of the parasites seeding the pastures. This trait is moderately heritable at approximately 0.30. The recent release of the sequence of the bovine genome is allowing us for the first time to identify the specific regions of the genome that affect susceptibility/resistance to the parasites. To date we have identified a total of 8 different regions on 6 different bovine chromosomes that contain potential structural variations that influence this trait. Current studies are aimed at the identification of markers h be used to make informed breeding decisions regarding parasite resistance and at characterization of the exact mechanisms of such resistance. Once this information is available it will be possible to include host resistance as one of the tools to increase production efficiency.



The combination of good management with optimal host genetics and the judicious use of chemical agents will allow the development of sustainable parasite control programs that will adequately control parasitism and insure the economic viability of the American cattle industry.

Pest Management Recommendations for Beef Cattle

Dr. Charlie Pitts
The Pennsylvania State University

INTRODUCTION

A variety of insect and mite pests affect the beef industry in the Northeast. House flies, stable flies, face flies, horn flies, horse flies, deer flies, cattle grubs, lice, and mange mites all are common and significant pests of cattle.
Insect and mite pest activity results in reduced feed conversion efficiency and decreased weight gains.. It exposes cattle to pathogenic microorganisms and causes blood loss and hide damage. It can lead to public health-public nuisance concerns.

Moreover, insect and mite pest pressure can add to stresses on young replacement animals, delaying their entry into production and adversely affecting lifelong production performance. As herd sizes increase on modern farms, pest pressures often are aggravated by large quantities of animal waste that must be handled and by crowded conditions that promote the spread of external parasites.

In the past, management of cattle pests often has relied on insecticide use as a single control tactic. But this single-tactic approach can aggravate insecticide resistance problems in pest populations and inadvertently destroy natural enemies of the target species. Modern beef producers are weaving careful use of pesticides into integrated pest management (IPM) programs.

IPM programs seek to maximize the effectiveness of pest control actions while conserving beneficial insects and minimizing pesticide use. The cornerstone of effective IPM is correct pest identification along with accurate and timely pest monitoring. Other components are various combinations of cultural, biological, and chemical control practices designed to keep pest populations below economically injurious levels. In the sections that follow, information is provided on pest biology, economic importance, identification, monitoring, and management. Control recommendations will be passed out on a separate handout.

FLIES IN AND AROUND LIVESTOCK BARNS
BIOLOGY AND IMPORTANCE

The two principal fly pests of confined livestock are house flies and stable flies. House flies, Musca domestica, are nonbiting insects that breed in animal droppings, manure piles, decaying silage, spilled feed, bedding, and other organic matter. They can complete their life cycle from egg to adult in 10 days under ideal conditions in summer months. Each female can produce 150 to 200 eggs, which she lays in batches at 3- to 4-day

intervals. Although house flies may be of only minor direct annoyance to animals, their potential for transmitting diseases and parasites is considerable.
Flies can also become a serious nuisance both around the production facility and in nearby communities. Demographic changes in the Northeast in recent years have placed many once-isolated farms in closer proximity to their neighbors. These new neighbors often are intolerant of flies, putting greater pressure on producers to keep house fly populations to a minimum.

The stable fly, Stomoxys calcitrans, is about the size of a house fly but is dark gray. Its abdomen has seven rounded dark spots on the upper surface. The adult's piercing mouthparts protrude spearlike from under the head. Stable flies breed in wet straw and manure, spilled feeds, silage, grass clippings, and in various other types of decaying vegetation. Each female fly lives about 20 to 30 days and lays 200 to 400 eggs during her lifetime. Under optimum conditions, an egg develops to an adult in about 3 weeks.

Cattle are most irritated by these pests during the warm summer months. Both male and female stable flies feed on blood several times each day, taking one or two drops at each meal. Stomping of feet is a good indication that stable flies are present, since they normally attack legs and bellies. Production performance declines in infested herds because of the flies' painful biting activity and animal fatigue from trying to dislodge flies.

MONITORING

House flies can be monitored using baited traps, sticky ribbons, or spot cards. Baited traps are gallon plastic milk jugs with four 2-inch holes cut in the upper part of the sides. The holes allow entrance of flies that are attracted to 1 ounce of methomyl fly bait placed on the inside bottom of the jug. The traps are suspended from rafters or other building supports with 18- to 24-inch-long wires. Spot cards are 3-by-5-inch white file cards that are attached to obvious fly resting surfaces (areas with large numbers of fly fecal and regurgitation spots).

The number of baited traps, spot cards, or sticky fly ribbons will vary according to facility size, but a minimum of five at equidistant locations throughout each animal housing unit should be used. These monitoring devices are left for 7 days. Then the number of flies collected in the traps or on the sticky ribbons, or the number of fecal and vomit spots on the spot cards, are counted.

Although any of these monitoring devices are effective, spot cards have the additional virtue of providing long-term historical records of fly activity. Old spot cards can be particularly helpful in resolving conflicts with neighbors over claims of increased fly abundance. In general, baited jug trap catches in excess of 250 flies per week, or spot card counts of over 100 spots per card per week, are considered high levels of fly activity.

House flies in the Northeast are active from May through October, with peak populations occurring from mid-July though mid-September.

Stable flies are monitored by counting flies on all four legs of about 15 animals in the herd. Treatment is warranted when counts reach an average of 10 flies per animal.

MANAGEMENT

CULTURAL CONTROL
A variety of cultural control practices can be used effectively to manage house flies and stable flies.

• Practice sanitation. The fly life cycle requires that immature flies (eggs, larvae, pupae) live in manure, moist hay, spilled silage, wet grain, etc., for 10 to 21 days. Removing and spreading fly breeding materials weekly helps to break the cycle. Waste management is therefore the first line of defense in developing an effective fly management program. It is much easier and less costly to prevent a heavy fly buildup than to attempt to control large fly populations once they have become established.

The prime fly sources in confinement areas are animal pens, especially those housing calves. The pack of manure and bedding under livestock should be cleaned out at least once a week. In free-stall barns the next most important fly breeding area is the stalls, which should be properly drained and designed to encourage complete manure removal. In stanchion barns, drops should be cleaned out daily. Wet feed remaining in the ends of the mangers, as well as green chop and other forage and feed accumulations around silos, breed flies and should be cleaned out at least weekly.

• Use sticky tapes, paper ribbons. Sticky ribbons, especially the giant ones, are very effective for managing small to moderate fly populations. Their only disadvantage is that they need to be changed every 1 to 2 weeks because they dry out, get coated with dust, or get "saturated" with flies.

• Prevent flies from emigrating from the facility. Again, fly location can be important, especially if housing and commercial developments have been built near the farm. Certain management practices can reduce fly breeding outdoors.

Spreading manure and bedding as thinly as possible will help ensure that it dries out quickly. If practical, it should be disked under as well to help kill fly larvae and pupae that may be present, especially if cool or overcast weather will slow the drying process. Drainage problems that allow manure to mix with mud and accumulate along fence lines in exercise yards should be eliminated. Gaps under feed bunks where moist feed can accumulate should be sealed.

BIOLOGICAL CONTROL

Female flies lay their eggs on manure, calf bedding, wet feed, or silage. The larvae hatch, and the maggots develop for about a week before they reach the pupal stage. Inside the pupa, which is protected by a hard reddish-brown shell, the developing fly goes through the metamorphosis from maggot to fly.

Flies have "natural enemies" that are commonly present in livestock barns. Beetles and mites devour fly eggs and larvae, adult flies are prone to diseases, and fly pupae are attacked by small parasitic wasps. Unnoticed and unaided by us, these natural biocontrol agents can take a heavy toll on the fly population.

Parasitic wasps are among the most important of these natural biocontrol agents. About a dozen species occur throughout the United States. Some species perform better in different climates, and some prefer different kinds of manure and other fly breeding materials. The species best adapted to barns in the Northeast is Muscidifurax raptor. This versatile species attacks fly pupae inside barns as well as outside, and it accounts for most of the naturally occurring wasps on our dairy farms.

Parasitic wasps are like "smart bombs" that live only to find and to kill fly pupae. Although the female wasp has a stinger, she cannot use it for anything except killing flies. When she finds a fly pupa, she first stings and feeds on it. This kills the fly. She then uses her stinger to lay an egg inside the pupa. The egg hatches and the parasite larva feeds on the dead fly. The young adult parasite then chews its way out of the fly's pupal case and resumes the search for new pupae to kill. Development from egg to adult parasite is completed in about 3 weeks.

Evolution has led to a natural balance that allows both the parasite and the fly to coexist. If we think of the fly and the parasite as competitors in a race each summer, the fly has certain advantages that help it to "win" unless we intercede to level the playing field. For example, the fly develops twice as fast from egg to adult, lives longer, and lays more eggs than Muscidifurax raptor parasites. As fly populations begin to grow in late May and early June, the parasite populations lag behind. The result is that the parasite population is usually behind that of the fly by several weeks.

The parasite also lags behind the fly in developing resistance to insecticides. Many insecticide treatments for the fly therefore have the undesirable side effect of killing large numbers of parasites. If you use insecticides highly toxic to natural enemies in the early summer, you can get stuck on a "pesticide treadmill." Each subsequent insecticide treatment kills more beneficial insects and creates conditions that require repetitive treatments to keep flies in check. This also aggravates the problem of insecticide resistance in the flies.

Parasite populations can be conserved by using insecticides that are compatible with these important biocontrol agents. Methomyl scatter baits and pyrethrin space sprays are good examples of compatible insecticides. Residual premise sprays such as permethrin, dimethoate, and rabon are highly toxic to parasites and should be used only as a last resort for dealing with occasional fly outbreaks.

Parasite Releases

Along with conserving natural enemies, it is possible to go one step farther and make releases of parasites to "jump-start" their population growth in the early summer. Releases of parasites can be effective in managing fly populations if certain conditions are met:

•Waste management is a must; parasite releases complement manure management but cannot replace it.

• When insecticidal treatment is necessary for supplemental fly control, only those insecticides compatible with parasites (space sprays and baits) should be used.

• Parasites are sent from suppliers as killed fly pupae containing immature parasites. Local suppliers ship the parasites in cheesecloth bags. If most fly breeding on the farm occurs inside the barn, these bags should be stapled to posts and rafters near areas where fly breeding is a problem. If calves are housed in hutches, the bags should be opened and about 3 heaping teaspoons of pupae placed in each hutch weekly.

Chemical Control

Insecticides can play an important role in integrated fly management programs. Chemical control options include space sprays, baits, larvicides, residual premise sprays, and whole-animal sprays. Check with your local extension agent for current pesticide recommendations

Space sprays with synergized pyrethrins or a combination of dichlorvos and synergized pyrethrins provide a quick knockdown of adult flies in an enclosed air space. Because space sprays have very little residual activity, resistance to these insecticides is still relatively low in fly populations in the Northeast. Scatter baits containing the insecticide methomyl are also very useful for managing moderate fly populations. As indicated previously, space sprays and baits are compatible with fly parasites.

A number of insecticides are labeled for use as larvicides, either for direct treatment of manure or in con trolled-release formulations. Direct application of insecticides to manure and bedding should be avoided in general, because of harmful effects on beneficial insects. The only exception is occasional spot treatment of breeding sites that are heavily infested with fly larvae but that cannot be cleaned out. Controlled-release larviciding options include boluses and feed additives that result in the insecticide's being excreted with animal feces.

Treatment of building surfaces with residual sprays such as permethrin, dimethoate, naled, and rabon has been one of the most popular fly control strategies over the years. High levels of resistance to these insecticides are now very common. These materials should be used sparingly and only as a last resort to control fly outbreaks that cannot be managed with other techniques. Whole-animal sprays can be made directly on the animals to manage stable fly problems. Although this approach can provide needed relief from biting fly pressure, the control is rather short-lived.

FLIES ON PASTURED CATTLE

BIOLOGY AND IMPORTANCE

Several fly pests attack cattle on pasture. These pests include horn flies, face flies, horse flies and deer flies, black flies, mosquitoes, and biting midges. Each has distinctive habits, life histories, and economic importance.

Horn Flies

The adult horn fly, Haematobia irritans, is about half the size of a house fly or stable fly. Both sexes have piercing mouthparts which they use to penetrate animal skin to obtain blood meals. Horn flies are intermittent feeders that take 20 or more small blood meals each day. The flies normally congregate on the shoulders, backs, and sides of the animals. During very hot or rainy weather the flies move to the underside of the belly.

Unlike most other flies, horn flies remain on the animals almost constantly, leaving only for very brief periods to lay eggs on very fresh (less than 10-minute-old) droppings. Development from egg to adult is completed in 10 to 20 days. The flies overwinter as pupae in or under dung pats. Horn flies can be a serious pest of pastured cattle by causing poor weight gain, blood loss, and animal annoyance and fatigue.

Face Flies

The face fly, Musca autumnalis, is a robust fly that superficially resembles the house fly. It is a nonbiting fly that feeds on animal secretions, nectar, and dung liquids. Adult female face flies typically cluster around the animals' eyes, mouth, and muzzle, causing extreme annoyance. Their activity around the animals' eyes allows face flies to serve as vectors of eye diseases and parasites such as pinkeye and Thelazia eyeworms. They are also facultative blood feeders, meaning that they gather around wounds caused by mechanical damage or biting fly activity to feed on blood and other exudates.

By contrast, male face flies feed only on nectar and dung. They spend much of their time resting on branches and fences and attempting to catch and copulate with female flies as they move about. Females lay their eggs on very fresh droppings on pasture, and development from egg to adult is completed in about 2 to 3 weeks, depending on temperature.

Face flies are strong fliers that can travel several miles. Unlike house flies, face flies do not enter darkened barns or stables during the summer months. In the fall, however, they enter buildings and overwinter indoors in a state of diapause, or hibernation.

Horse Flies and Deer Flies

Horse flies and deer flies belong to the fly family Tabanidae. They represent a complex of at least 300 species, some of which are very pain-inflicting and annoying pests. Dairy cattle on pasture occasionally are severely attacked by these flies, particularly on pastures that border woodlands or wet, marshy areas. Female horse flies and deer flies cut through the skin of the animal with knifelike mouthparts. They then feed on the blood that pools around the wound. The wound continues to bleed after the fly leaves and often attracts face flies.

Large numbers of these flies can cause extreme annoyance and fatigue, blood loss, reduced milk production, and reduced weight gain. Some species have also been implicated in the transmission of tularemia, anthrax, anaplasmosis, and leukosis. Female flies typically lay their eggs in distinctively shaped egg masses on vegetation near marshes, ponds, or streams. Development from egg to adult requires 70 days to 2 years, depending on the species.

Other Biting Flies

(black flies, mosquitoes, biting midges) Black flies belong to the family Simuliidae, which includes at least 700 different species. Most are gener-alist feeders that attack cattle as well as humans, deer, and other animals. Black fly larvae live in clean, fast-moving water such as streams and dam outfalls.

Mosquitoes also belong to a large family, the Culicidae, which includes numerous species that attack cattle and other animals. Mosquito larvae live in permanent and transitory standing water, including ponds, tree holes, drainage ditches, and stockpiled tires. Although dairy cattle are sometimes attacked by large numbers of these pests, such problems tend to be very local and short lived.

Biting midges, also called "no-see-ums" or punk-ies, are tiny biting flies in the family Ceratopogonidae. Adult flies feed on blood, and larvae feed on decaying organic matter in moist soil habitats. Ideal breeding grounds are sometimes created where manure mixes with mud around cattle watering areas and manure lagoons. In some regions of the country, biting midges also transmit the virus that causes bluetongue disease.

MONITORING

Horn flies are monitored by counting flies on the heads, shoulders, backs, and sides of at least 15 animals; counts in excess of 50 flies per side warrant insecticidal treatment. Face flies are monitored by counting flies on the faces of 15 pastured animals; average counts in excess of 10 flies per face are considered economically injurious. No action thresholds are known for tabanids, mosquitoes, black flies, or biting midges.

MANAGEMENT

horn flies and face flies

Horn flies and face flies breed exclusively in very fresh droppings on pasture. As a result, cultural controls such as manure management practices in and around barn areas that are highly effective against house flies and stable flies will have no impact on horn fly and face fly'populations.

Biological control against these pests at present is limited to beneficial organisms that occur naturally in the field. Face flies are attacked by parasitic nematodes, and immature stages of both horn flies and face flies are attacked by predaceous mites, predaceous beetles, and parasitic wasps. Manure competitors such as dung beetles also limit fly populations by removing and burying cattle dung before immature flies can complete their development. Adult flies are attacked by predaceous yellow dung flies, and face flies are occasionally attacked by pathogenic fungi.

In spite of the diversity and importance of natural enemies of face flies and horn flies, methods are not known for exploiting these biological control agents in pest management programs. Parasite releases for house fly and stable fly control are not effective against these pasture pests.

Insecticidal control options for horn flies and face flies include whole-animal sprays, self-applicating devices, feed-through insecticides and growth regulators, and controlled-release devices, such as ear tags and tapes. Check with your local extension agent for current pesticide recommendations.

Whole-animal sprays provide rapid relief from fly pressure. Animal sprays are applied either as a dilute coarse spray, often applied under high pressure to soak the skin, or as a fine low-volume, more concentrated mist.

Self-applicating devices include back rubbers covered with an absorbent material treated with an insecticide-oil solution, or dust bags filled with an insecticidal dust. Back rubbers and dustbags should be placed in gateways, near water and feed sources, and in other areas where animals will make frequent contact with them.

Feed-throughs include insecticidal feed additives, treated mineral blocks, and bolus formulations. These treatments are generally less effective for face flies than for horn flies. In either case, feed additives have no effect on adult flies that are already present or that may immigrate from neighboring farms. Unless your farm is very isolated or you are participating in an area-wide management program, feed-throughs may not provide satisfactory fly suppression.

Controlled-release ear tags and tapes are generally very effective for horn fly control in the Northeast, and they often reduce face fly pressure as well. Because these products have not been used extensively in the Northeast, insecticide resistance is not a major concern at present. But in other parts of the country, high levels of resistance have developed in horn flies to pyrethroids such as permethrin, fenvalerate, resmethrin, and fluey thrinate. You can prevent horn fly resistance from becoming a serious problem by following guidelines developed by a panel of experts in the field. These guidelines include the following:

• Do not treat unless flies exceed threshold levels.

• Use organophosphate insecticides, such as rabon or cournaphos, for early-season horn fly control, and reserve ear tags for late summer use.

• Remove ear tags in the fall to reduce development of resistance to low levels of pyrethroids.

Although ear tags and boluses are controlled-release application methods, the amount of active ingredient they release decreases over time. Because of this, timing of ear tag and bolus placement is important. If at all possible, delay using these application methods until July so there will still be enough active ingredient left in mid-August, when horn fly populations reach their peak. Early tagging or bolusing of heifers at the time they are placed on spring pasture in April or May will greatly reduce the effectiveness of these treatments later in the summer when it is needed the most.

Other Pasture Flies

Horse flies and deer flies are notoriously difficult to control. They are strong fliers that move large distances between breeding areas and hosts. Because they land on host animals to feed for only a very short time, it is difficult to deliver a lethal dose of insecticide to them during their episodic host attacks.

Moreover, because livestock represent only one of many host animals these pests feed on, treating the cattle will have a negligible impact on total fly populations. Severe horse fly and deer fly pressure is generally temporary because of the seasonally of fly activity. In some cases, cattle can be moved from low-lying pastures near marshy areas to other pastures where fly pressure is less during these periods of peak activity.

Mosquitoes, black flies, and biting midges are also difficult to control. Strategies such as boluses and feed additives that are aimed at fly larvae have no effect on any of these pests because the immature stages do not occur in animal droppings. Whole-animal sprays and pour-ons can provide temporary relief in some cases from horse flies, deer flies, mosquitoes, etc.; read product labels carefully to see which ones claim to control or "aid in the control of" these pests.

CATTLE GRUBS

BIOLOGY AND IMPORTANCE

Cattle grubs are the larval stage of heel flies. Two species of these flies occur in the Northeast: the common cattle grub (Hypoderma lineatum) and the northern cattle grub (Hypoderma bovis). Both have similar life cycles. Adult flies emerge during the spring and summer. They are large, hairy flies that resemble bees. After mating, the females locate cattle on which to lay their eggs. Egg laying occurs between late May and August. Cattle often panic in the presence of the fast-moving flies and may run wildly with their tails high in the air in an effort to escape. In spite of this gadding response by cattle, the flies neither bite nor sting the animals. In fact, the adults do not feed at all and survive only 3 to 8 days.

Female flies attach their eggs to the hairs of the cow's legs and lower body regions (hence the term "heel fly"). Each can lay up to 600 eggs, which hatch in 4 to 7 days. Newly hatched larvae burrow into the skin, causing the animal considerable irritation. The young larvae then migrate through the animal's connective tissue. By November 1 most larvae of the common cattle grub have migrated to the submucosa of the esophagus, whereas those of the northern cattle grub migrate to the epidural tissues of the spinal canal.

During the winter months, the larvae of both species migrate again, this time into the animal's back. By February most larvae have reached the back and have cut a breathing hole through the hide. There the larva forms a warble (swelling) between the layers of the hide. Within the warbles, the grubs grow rapidly for about two months, reaching a final size of about an inch in length.

Young animals are more heavily infested with grubs than mature milking cows are, because older animals develop a degree of immunity to the grub larvae. When mature the grubs emerge through the breathing holes, drop to the ground, and pupate in pasture litter and soil. During this stage the grub's skin hardens and turns black. The metamorphosis from grub to adult fly takes from 2 to 8 weeks. Adult heel flies emerge from the pupae and are active from late May through August. Most activity occurs during June and July.

Economic losses to cattle grubs take several forms. First, gadding behavior in response to adult fly activity decreases the animal's ability to graze efficiently. Gadding also makes cattle difficult to handle and increases the risk of self-inflicted injuries. Second, tunneling by cattle grub larvae through the animal's tissues causes great damage. Heavy infestations in replacement animals can result in poor weight gain and long-term production losses.

Third, the breathing holes cut by the grubs damage the most valuable portion of the hide, substantially decreasing its value at slaughter. Moreover, the meat surrounding the warbles is discolored and must be trimmed at the slaughter house, further reducing the carcass's value.

MONITORING

Backs of cattle should be examined during March and April for the presence of warbles. Warbles are detected by rubbing the cow's backline and feeling for the cystlike bumps. When the hair around a warble is parted, the breathing hole may be visible. Because animals develop some immunity to infestation by grubs, the most important animals to examine are those under 5 years of age. Calves born after the fly season and animals kept indoors during the summer will not have cattle grubs and need not be monitored. Gadding behavior during late spring and summer indicates that female heel flies are laying eggs. Pastured animals may also be examined for the presence of eggs on the hairs of the animal's legs, udder, escutcheon, thighs, and rump.

MANAGEMENT

Cattle confined in barns from May to August are protected from cattle grubs, because heel flies do not enter barns to lay their eggs. But individual production and management practices often rule out this method of cultural control. The most effective method of actually reducing fly populations is to organize a community-based, area-wide program for treating all nonlactating cattle with systemically active insecticides. Such an area-wide treatment can substantially reduce heel fly activity the following year.

In the absence of regional control programs, individual producers may minimize damage to their own animals by using systemically active insecticides on their young, nonlactating heifers. Several systemic insecticides are available as pour-ons, spot-ons, and injectables..

Proper timing is critical for the safe, effective use of systemic insecticides. Treatment must be made after adult heel fly activity ceases, but before the migrating grub larvae reach the esophagus or spinal cord. This means that systemics should be used in September, and never after November 1. Treatments made after November 1 may cause severe allergic reactions in the animals, resulting in bloat, paralysis, and death. A list of systemic insecticides for grub control is presented in Table 3.

CATTLE LICE

BIOLOGY AND IMPORTANCE

In contrast to the fly pests, lice are relatively small and inconspicuous. Four species of lice attack dairy cattle in the Northeast. By far the most common is the cattle chewing louse, Bovicola bovis. This species is about 1/8 inch long when fully grown, has a yellow-brown appearance, and is most commonly found on the animal's neck, back, hips, and tailhead. B. bovis are not blood feeders, but they use their mouthparts to rasp away at animal skin and hair.

In addition to chewing lice, several species of sucking lice feed on the blood of beef cattle with the short-nosed cattle Haematopinus eurysternus being the most important Sucking lice have mouth-parts specialized for penetrating animal skin. They spend most of their time with their heads firmly attached to the skin. Sucking lice often take on a darker appearance than chewing lice as they become engorged with blood.

Female lice lay their eggs by attaching them to hairs with a strong glue to prevent them from falling off. The eggs, known as nits, hatch in 10 to 14 days, and the young lice (nymphs) complete their development within several weeks. Lice, in contrast to some other livestock pests, are permanent parasites that spend their entire lives on the host animal.

All four types of lice cause extreme annoyance to the host animals. Milk production declines in heavily infested cattle, and the animals' preoccupation with rubbing leads to hair loss, reduced feed conversion efficiency, and general unthriftiness. Infested animals become irritable and difficult to work with,. People working around lousy animals are exposed to greater risk of injury and are also annoyed by stray lice they pick up from infested animals during handling.

Although louse problems are generally perceived as being most severe during the fall and winter months, animals of different age groups show distinct differences in the seasonally of infestation. Lice are most common on mature cows in December through March, with peak populations found in March. In contrast, calves housed inside barns show high levels of infestation throughout the year, with peak populations in June

MONITORING

Because lice often are inconspicuous, many producers do not detect them until their cattle begin to show hair loss from the animals' grooming activities. But by the time the infestation has progressed to this stage, populations of lice are already well above economic injury levels, and treatment becomes very difficult owing to the large numbers of lice involved. Effective management of cattle lice below economic injury levels requires sampling of apparently healthy as well as noticeably lousy animals for the presence and relative numbers of lice. Such surveillance should be conducted every 2 to 3 weeks throughout the fall, winter, and spring months. Lice can be monitored easily with a flashlight and a little practice. Sampling involves carefully inspecting sections of skin on a representative sample of animals in the herd, either 10 percent or 15 animals in each group: mature cows, heifers, and calves. The best regions to inspect are the head, neck, shoulders, back, hips, and tail. If sampling indicates that B. bovis is the dominant species present, assessment of the neck and tailhead alone is sufficient to detect most infestations. Treatment is recommended when counts average over 10 lice per square inch.

MANAGEMENT

Cultural Control

Producers can save on the cost of insecticide treatments for lice by adopting cultural control practices. First, replacement animals brought into the herd should be isolated and carefully inspected for lice before they are allowed to mingle with the rest of the herd. Second, careful and regular monitoring for lice can detect problems before an infestation gets out of control.

Chemical Control

Many insecticides and application procedures are effective for managing lice. As with any insecticide application, it is essential to consult the label to ensure the insecticide is registered for use on beef cattle, and if so, whether it may be used on lactating animals. Before selecting an insecticide, consider how it can be applied to meet individual needs and production practices. There are several categories of application methods: self-application devices, whole-animal sprays, pour-ons, and dusts.

Self-application devices such as dust bags must be placed in areas where animals will contact them frequently and treat themselves with repeated, small doses. Whole-animal sprays have the advantage of ensuring good coverage over the entire animal's body. But severe louse problems on mature animals are most common in winter, and it generally is wise to avoid soaking animals in periods of cold weather. Applications with foggers and mist blowers can overcome these problems. With these types of applications, a small quantity of concentrated pesticide is propelled as an aerosol made up of very small spray particles. The concentrated aerosol can then be applied evenly over the animal's body, greatly reducing the amount of liquid used.

Another method of application is the use of pour-on insecticides, in which a small quantity of pesticide is poured down the backline of the animal. The most popular application method for lice is dusting by hand. Dusts are easy to apply, require no mixing, and can be used year-round.

Insecticides must be used properly to achieve satisfactory control of lice. Many louse-control products require two treatments, 10 to 14 days apart. The second treatment is essential to kill newly hatched lice that were present as eggs at the time of the first treatment and were therefore not killed. Failure to make the second treatment in a timely manner will create problems requiring many more subsequent treatments.

MANGE MITES
BIOLOGY AND IMPORTANCE

One economically important species of mites infest beef cattle in the Northeast

Sarcoptic Mange

Sarcoptic mange is a condition caused by Sarcoptes scabiei. The skin lesions arising from infestation by these mites are so severe that sarcoptic mange is handled as a quarantinable disease.

Unlike lice and Chorioptes mites, the microscopic sarcoptic mange mites burrow deeply into the skin, laying eggs inside the burrows. The eggs hatch into the larval stage. The larval mites then leave the burrows, move up to the skin surface, and begin forming new burrows in healthy skin tissue. Development from egg to adult is completed in about 2 weeks. The lesions resulting from infestations by these mites are a consequence of the reaction of the animals' immune system to the mites' presence. Because of the intensity of the animals' immunological response, it takes only a small number of mites to produce widespread lesions and generalized dermatitis. Animals show remarkable variation in the extent to which they react to the infestation, however. It is not uncommon to have healthy-looking animals in stanchions next to animals with lesions over much of their bodies.

MONITORING

Mange lesions often first appear around the tail, anus, thighs, udder, legs, and feet. The first sign of infestation usually is hair loss from the animals' rubbing as they try to relieve the itching. As the infestation progresses, the lesions become larger and bloody or moist, followed by the formation of thick, crusty scabs. If left untreated, the lesions may eventually cover the animal's body. When this happens, the entire hide may take on a thick, wrinkled appearance.

Sarcoptic mange mites are nearly invisible to the naked eye. In addition, mange is only one of several conditions resulting in somewhat similar symptoms. The only way to diagnose mange accurately is by having skin scrapings taken by a veterinarian or other trained professional. Scrapings are made with a scalpel by abrading rather deeply into the skin. The scrapings are then brought back to the laboratory and examined under a microscope for the presence of mites and for species determination.

MANAGEMENT

Prevention

Mange mites, like lice, are permanent external parasites that do not survive away from the host for very long. The best way to minimize the risk of introducing the mites into a herd is to be cautious when buying or boarding new animals. Avoid any animals that show visible skin lesions or that appear to be abnormally itchy or agitated. As an extra precaution, it is wise to segregate all newly purchased animals from the rest of the herd for several weeks and keep them under observation. A veterinarian should be called in if any of the animals show signs of unusual itchiness.

Chemical Control

Several pesticides used for controlling cattle lice also are effective against chorioptic mange mites. Because of the severity of sarcoptic mange, it is regarded from a regulatory standpoint as a reportable disease. Therefore, the threshold for placing a herd under quarantine is the discovery of a single mite on one animal.

Once a herd has been placed under quarantine, animals may not be moved off the farm except for slaughter. Every animal in the herd must then be treated with high-pressure hydraulic spray equipment by certified pesticide applicators under the supervision of a state veterinarian. Either two or three treatments must be made, depending on the choice of insecticide used, with treatments spaced 7 to 10 days apart. Quarantine is lifted when post-treatment skin scrapings demonstrate the infestation has been eradicated. Because high-pressure spray equipment is necessary to ensure penetration by the spray into the skin, "home remedies" applied with low to moderate pressure gear of the type are never successful.

Additional Readings

http://www.ars.usda.gov/Services/docs.htm?docid=1013
http://www.ianrpubs.unl.edu/epublic/pages/index.jsp?giveNotFoundMessage=1&what=subjectAreasD&subjectAreasId=24#livestock
http://www.entomology.cornell.edu/Extension/Vet/index.html
http://www.uky.edu/Ag/Entomology/entfacts/eflivstk.htm

Mineral Deficiencies and Supplementation in Beef Cattle

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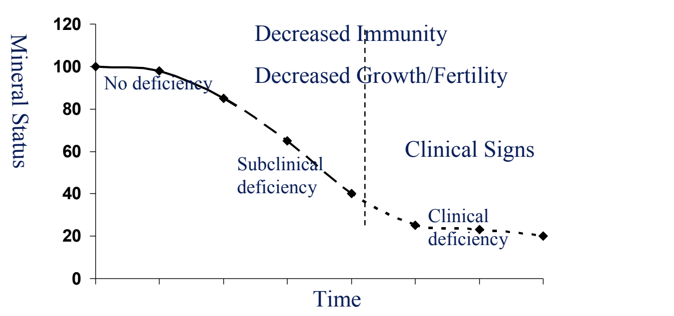
Minerals are critical nutrients in beef cattle diets. Even though a large percentage of the minerals needed by cattle can be obtained from the diet, variations in soil type, forage species, forage management, and soil fertility can greatly influence dietary mineral content of the grazing and hay. In addition, common protein and energy supplements fed to cattle also vary widely in mineral content.

A basic understanding of mineral nutrition and needs of cattle can help managers make sound decisions on mineral supplements. Making informed decisions can improve cattle performance while decreasing feed costs. There are very few instances where we actually see a clinic mineral deficiency in beef cattle. The two most common clinic mineral deficiencies are magnesium (grass tetany) and selenium (white muscle disease) which both can result in the death of animals. More likely most of the mineral deficiencies in our herds are subclinical. In other words, we cannot assign a particular disease or event to a deficiency but we notice less than optimal performance. Producers may notice an increase in rough hair coats, decreased pregnancy rates, more pinkeye, decreased immune function, and other decreases in production that can't necessarily be traced to a deficiency in a particular mineral. However, minerals <u>may</u> be involved in these situations.

Figure 1. Effects of Mineral Deficiency on Cattle Performance



Adapted from Wilkse, 1992 TAMU

Mineral deficiencies are a function of amount of mineral consumed, mineral requirement, mineral bioavailability, and the animals' ability to store the mineral. As mineral status decreases over time, animals move from a state of no deficiency to subclinical deficiency (Figure 1). Eventually, if the deficiency continues long enough animals will exhibit clinical signs of that mineral deficiency. The amount of time it takes for the deficiency to occur depends on the mineral. For example, copper is readily stored in the liver of cattle so it may take months of consuming insufficient amounts of copper for an animal to become deficient. That's why copper deficiency and its effects happen slowly and are often difficult to notice or pinpoint. In contrast, magnesium is poorly stored in the body. When grazing lush forages, which are Mg deficient, lactating cattle require Mg supplementation almost daily. This is why lactating cows can "come down" with grass tetany in only a few days without Mg mineral supplementation.

Mineral Availability

As indicated before, the minerals that are deficient on your farm are highly dependant on soil fertility and management factors. Testing mineral content of forages on your farm and understanding the mineral content of other feeds used is important when deciding on a mineral supplement. Several local cattlemen's groups have worked with their Extension agent and Extension specialists to design mineral supplements or recommendations for their particular area. For example, the mineral content of fescue growing on the red clay soils of the Piedmont is different than orchardgrass/red clover mixtures growing soils in the Shenandoah Valley. The minerals that are usually deficient or marginally deficient in the MidAtlantic are listed in Table 1.

Table 1. Deficient Minerals In the MidAtlantic

Deficient	Marginal
■ Copper	■ Calcium
■ Selenium	■ Phosphorus
■ Sodium	■ Magnesium
■ Zinc	■ Iodine

Adapted from Wahlberg

In contrast to the east, Horn (2005) found that Wyoming range was generally adequate in calcium, potassium, iron, sulfur, and copper. These range grasses were deficient in phosphorus, magnesium, manganese, and zinc. Even across ranches and seasons there were differences in the adequacy of minerals. Researchers in Montana, analyzed range grasses and determined that P, Na, K, Zn, and Cu were the minerals that were most likely deficient (Grings et al., 1996). Concentration of selenium in western range forage is often adequate. Some range forages can accumulate toxic levels of selenium as can some water sources in the region (a.k.a. alkali poisoning). Therefore, across the country and even within regions, there are vast differences in mineral content of forages.

Grazing management can also affect mineral content of forages. The macro-mineral content of most forages decreases with increasing maturity (Table 2 & 3). However, Mg content appears to be relatively constant. It is important to note the differences between grasses and legumes in mineral content. Legumes accumulate Ca and are a good source of this mineral. Grasses tend to have more P content. Mineral content of both grasses and legumes are dependant on soil fertility and pH. Changes in pH can affect trace mineral availability. For example, low pH soils increase availability of iron, manganese, zinc, copper, and cobalt to the plant. On the other hand below pH 6, iron, aluminum, and magnesium ions can fix P making it unavailable to the plant.

High mineral content of the plant does not always equal high availability to the animal. Minerals are often bound to proteins, sugars, acids, or fiber in the plant. The classic example is phosphorus. Phosphorus exists in grains bound in the phytic acid form. Non-ruminants cannot free the phosphorus from this form because they lack phytase, so total dietary P (grain + supplement) has to be well above requirements to get enough P into the animal. Ruminants have phytase so plant P is more available to them. Estimates of availability of minerals from forages are Ca (30 to 60%), P (64 to 70%), Mg (16 to 30%), K (90%), and Cu and Zn (50%) (Adapted from J. Linn, UMN and R. Rasby, UNL). The mineral requirements developed by the NRC take into account availability of minerals from a "normal" diet. In other words, normal diets were fed to animals and then mineral supplements added to those diets and performance or tissue levels of minerals measured. Mineral nutritionists are continuing to investigate mineral availability from plants as well as mechanisms of mineral absorption.

Table 2. Influence of maturity on protein and mineral content of orchardgrass

Constituents (% DM)	Leafy	Bud	Early Bloom	Late Bloom	Seeding
Crude Protein, %	33.9	17.6	10.1	7.8	6.1
Phosphorus, %	0.41	0.30	0.23	0.20	0.17
Potassium, %	3.90	2.86	2.47	1.87	1.63
Magnesium, %	0.21	0.19	0.13	0.14	0.18
Calcium, %	0.47	0.36	0.26	0.35	0.42

From Blazer et al., 1984

Table 3. Influence of maturity on protein and mineral content of red clover

Constituents (% DM)	Leafy	Bud	Early Bloom	Late Bloom	Seeding
Crude Protein, %	29.3	20.5	19.5	14.0	13.2
Phosphorus, %	0.32	0.25	0.21	0.15	0.15
Potassium, %	3.48	3.17	2.14	1.39	0.85
Magnesium, %	0.38	0.41	0.37	0.43	0.29
Calcium, %	1.38	1.31	1.42	1.61	1.58

From Blazer et al., 1984

In addition to affects of plant mineral content on availability of minerals, there are multiple interactions among minerals which affect mineral status of the animal (LeDoux and Shannon, 2005; Paterson and Engle, 2005). The primary mineral antagonisms of importance to grazing beef producers reduce the availability of copper or zinc to the animal.

Antagonistic effects of iron

Copper-iron and zinc-iron interactions affect availability of Cu and Zn to the animal. High concentrations of iron (> 400 ppm) in the diet will impair copper status from reduced copper uptake (NRC, 1996; Paterson and Engle, 2005). However, dietary iron concentrations ranging from 250 to 1,300 ppm have been reported to affect copper status (Spears, 2003). Zinc absorption may be impaired by iron as well. Iron is readily available in most forages in the US and does not need to be supplemented in most cases. Excessive dietary iron can result from consumption of soil, forage, and/or water containing high concentrations of iron. In most cases, the antagonistic effects of excessive iron can be reduced or eliminated by enhance supplementation of copper or zinc.

Antagonistic effects of sulfur and/or molybdenum

Sulfur can impair copper status through copper-sulfur or copper-sulfur-molybdenum interactions. Water, fertilizers, sulfur containing supplements (i.e. sulfate forms of minerals, sulfur containing amino acids), and even acid rain can increase sulfur intake of grazing animals. Diets with sulfur levels of > 0.30 % appear to reduce absorption of copper.

Molybdenum can also interfere with copper utilization especially when combined with high levels of sulfur. This copper-sulfur-molybdenum antagonism forms thiomolybdates which make the minerals unavailable to the animal or increases the rate of Cu depletion from tissues (Paterson and Engle, 2005). Research from Florida indicated that cane molasses based supplements contained sufficient S and Mo to reduce liver Cu in heifers and perhaps decrease performance of steers (Arthington, 1996). Administration of high levels of Cu supplementation were not able to counteract the effects on CU depletion; however, the author concluded that performance of heifers was not compromised and the animals would rapid regain liver Cu at the termination of winter molasses supplementation. Producers need to be aware of S and Mo levels in the diet including water.

Molybdenum may also directly result in copper deficiencies if the ratio of Cu to Mo falls below 2:1 (Miltimore and Mason, 1971). Molybdenum concentrations are not normally in the range to cause problems. However, recent work we have conducted indicates that pastures repeatedly fertilized with biosolids may have high levels of Mo. The levels we have encountered on a very few farms were between 4 and 9 ppm. These levels are high enough to cause Cu deficiencies especially combined with high sulfur. Manures and biosolids are useful fertilizers for pastures. Producers should not avoid using these fertilizers, but they need to be careful to monitor mineral content of forages grown with manure or biosolids.

Availability as affected by form of mineral

There is often much debate about which form of the mineral should be used (chelate/organic vs sulfate, etc). The research is clear on several aspects. First, the ability of the animal to absorb mineral forms is chelated ≥ sulfate >> oxide. So, chelated or organically bound minerals are the most readily absorbed form. However, research indicates that in most situations the absorption rate of sulfate forms of the mineral are sufficient to meet animal needs, and for some minerals the oxide form is fine (i.e. FeO, MgO). The organically bound minerals are most beneficial during times of high stress (weaning), poor feed intake, or severe mineral antagonisms.

Feeding chelated forms of Zn, Mg, and Zn to cattle consuming water high in sulfates improved feedlot and carcass performance compared to cattle receiving a control diet (Vazquez-Anon et al., 2007). The control diet contained recommended amounts of Zn, Cu, Mg, and Se for growing cattle, but supplemented cattle received higher concentrations than controls. Cattle receiving extra trace minerals had decrease mortality and morbidity in the feedlot, and produced fewer dark cutting carcasses. In contrast, supplementation of steers with organic forms of Zn, Cu, and Mn did not improve measures of immune function (Dorton et al., 2007) or carcass characteristics (Whitman et al., 2007) compared to steers receiving sulfate forms of these trace minerals.

Animal Requirements

Animal mineral requirements are dependent on several factors including age, growth rate, production status (lactating, pregnant, etc), health, and previous mineral supplementation. In general, lactating cows will need higher levels of calcium and phosphorus than stocker cattle. Finishing cattle with high rates of gain will require greater amounts of calcium and phosphorus than lactating cows Tables 4, 5 & 6 illustrate the differences in requirements that occur with different age, sex, or production status. Note that most of the differences among animal types are in macro minerals such as calcium and phosphorous. It is also important to remember that these requirements are the concentrations required in the entire diet. These ARE NOT the numbers you should look for on the mineral bag!

Table 4. Macro mineral requirements for different classes of cattle (% of dietary dry matter)

Mineral	**Cows - Lactating**	**Cows - Dry**	**Heifers & Bulls**
Calcium, %	0.31-0.22	0.15-0.26	0.28-0.34
Phos., %	0.21-0.15	0.12-0.16	0.19-0.24
Magnesium, %	0.20	0.12	0.10
Potassium, %	0.70	0.60	0.60
Sodium, %	0.10	.06-.08	0.08
Sulfur, %	0.15	0.10	0.15

Table 5. Impact of average daily gain on Ca and P requirements of finishing cattle (% of dietary dry matter)

Mineral	**0.7 lbs ADG**	**1.8 lbs ADG**	**2.8 lbs ADG**	**3.5 lbs ADG**
Calcium, %	0.22	0.36	0.49	0.61
Phos., %	0.13	0.19	0.24	0.29

Table 6. Trace mineral requirements of cattle (ppm in the diet)

Mineral	**All sexes and stages**
Copper, ppm	10.0*
Cobalt, ppm	0.10
Iodine, ppm	0.50
Iron, ppm	50.0
Manganese, ppm	20.0-50.0
Selenium, ppm	0.10
Zinc, ppm	30.0

* Requirement is higher for Simmental cattle

Supplementation Strategies for Pasture Fed Beef Operations

As indicated previously, many factors impact which mineral supplement is the right one for your operation. The old method of "just give 'em plenty" is a poor strategy due to cost, mineral interactions, and environmental considerations. A strategic approach to supplementation would include the follow steps.

1. Decide on the level of performance (ADG) that is the goal for your operation
2. Take forage samples analyze for CP, ADF, NDF, Ca, P, K, Na, Mg, S, Cu, Fe, Mn, Se, Zn. Several samples may be needed across forage types and seasons.
3. Analyze water samples for mineral content if indicated.
4. Examine results for potential deficiencies and antagonisms.
5. Identify energy or protein supplements needed to achieve ADG goals. All supplements should have a full mineral analysis as well.
6. Develop a diet with the assistance of a consulting nutritionist or Extension professional
7. Work with your local mill or mineral supplement provider to identify a mineral formulation that meets the needs of your cattle. If all else fails order a custom mix.
8. Weigh the costs and benefits of particular forms of mineral.
9. Monitor animal performance and mineral intake.

Mineral content of mineral mixes may need to be adjusted when feeding special feeds or greater than 3 to 5 lbs of concentrate per animal per day. For example, by-product feeds such as corn gluten feed, soyhulls, or wheat midds are high in phosphorus. Therefore, to keep the calcium phosphorus ratio correct and to reduce excess phosphorus in the environment, supplementation of P will generally not be needed. Distiller's grains have the greatest concentration of P of all by-product feeds. Producers should work with their Extension professional or nutritionist to design mineral supplements for these situations. For example, our replacement heifers and finishing steers receive a free-choice mineral that contains no P when we are feeding them significant amounts of corn/corn gluten feed mix.

Trouble shooting

If animal performance or health appears to be sub-optimal, then producers may want to take the following steps when considering a potential mineral problem.

1. Rule out all other nutritional deficiencies – protein, energy, forage quantity and quality
2. Review mineral program, sources, and dietary calculations
3. Eliminate disease related causes. Review herd health program and biosecurity program with local veterinarian.

4. Re-examine cattle type and genetics relative to environment
5. Work with veterinarian to obtain tissue or blood samples for mineral analysis to ascertain mineral status of animal.

Mineral Costs and Feeding Management

It appears the "Discount-mart mentality" of cheaper is always better pervades every aspect of our society these days. Decisions on mineral supplementation appear to not be immune to this theory. While I am certainly a believer in getting the most for your money and reducing production cost, beef producers should consider the true impact of mineral cost on animal cost and weigh that against the mineral content and form of mineral. If the cheap bag is primarily oxide forms of minerals and may not have recommended levels of some trace minerals, then it may not be the best buy. Similarly, if the expensive mineral contains mainly organic forms of trace minerals but the animals can't benefit from the added availability (or don't need it), then money has been wasted.

A comparison of yearly mineral cost per cow based on mineral consumption and mineral cost is shown in Table 7. The relative impact of increasing the cost of a 50 lb bag of mineral by $2.50 per bag on yearly animal cost is relatively small. Buying a mineral (4 oz consumption) that costs $12.50 per bag compared to $10.00 per bag only increases animal costs by $ 4.55 per year. Therefore, increasing animal cost by 1.3% if annual animal cost is $ 350/head.

Table 7. Impact of mineral cost and daily mineral consumption on annual mineral cost per head

	Cost of Mineral (50 lb. Bag)				
Daily Mineral Consumption	**$ 5.00**	**$ 7.50**	**$ 10.00**	**$ 12.50**	**$ 15.00**
2 oz/cow/day	$ 4.56	$ 6.84	$ 9.13	$ 11.41	$ 13.69
4 oz/cow/day	$ 9.13	$ 13.69	$ 18.26	$ 22.81	$ 27.38
6 oz/cow/day	$ 13.69	$ 20.53	$ 27.38	$ 34.23	$ 41.06

Beef producers can control their mineral costs more effectively by monitoring mineral consumption. For example, if cattle eat 6 oz instead of a "4 oz" mineral that costs $10.00 per bag then annual cow mineral cost increases by $ 9.12. Regular checking of mineral feeders and keeping track of the number of days it takes cattle to consume mineral is important to proper supplementation and cost control. Remember that cattle do not consume mineral in a regular fashion. They may eat mineral only every several days, but then consume 8 to 12 oz.

If cattle are over consuming mineral (and they have not been mineral deprived) then strategies to decrease mineral consumption should be taken. Mineral feeders that are too close to water increases mineral consumption. Just think how many more salty pretzels you can eat if you have plenty of pop or your favorite barley-based beverage available? Also, some mineral formulations increase consumption by adding palatability enhancers (molasses, brewer's grains). Usually palatability enhancers are added to offset a bitter component such MgO. These formulations can sometimes taste too good to cattle, and another formulation may need to be purchased. If cattle are under-consuming minerals then move feeders closer to the water source or add a palatability enhancer.

What if I want more in-depth information?

Certainly, I have given the production-management perspective on this subject rather than the classically trained nutritionist version. For those of you that are seeking more information on beef cattle mineral nutrition or mineral antagonisms, I suggest the following reviews.

- Trace Mineral Bioavailability in Ruminants by Dr. Jerry Spears from NC State University
- Bioavailability and Antagonists of Trace Minerals in Ruminant Metabolism by Dr. David LeDoux
- Trace Mineral Nutrition in Beef Cattle by Drs. John Paterson and Terry Engle, Montana State and Colorado State Universities
- Nutrient Requirements of Beef Cattle by National Research Council

Summary

Mineral supplementation (esp. Ca, P, Cu, I, Mn, Se, Zn) is important, growth performance, immune function and perhaps carcass qualtiy. Supplementation of macro minerals will depend on forage mineral content, stage of production, and other feeds in the diet. Effective and cost efficient supplementation requires knowledge of the mineral composition of the main feeds in the diet and the nutrient needs of the animal. Producers should seek assistance from Extension professionals or nutritionists when designing a mineral program. Keeping mineral supplements available to animals at all times as well as monitoring and managing intake are important to a successful beef operation.

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Vaccine Basics and Strategies for Grass-Fed Cattle.

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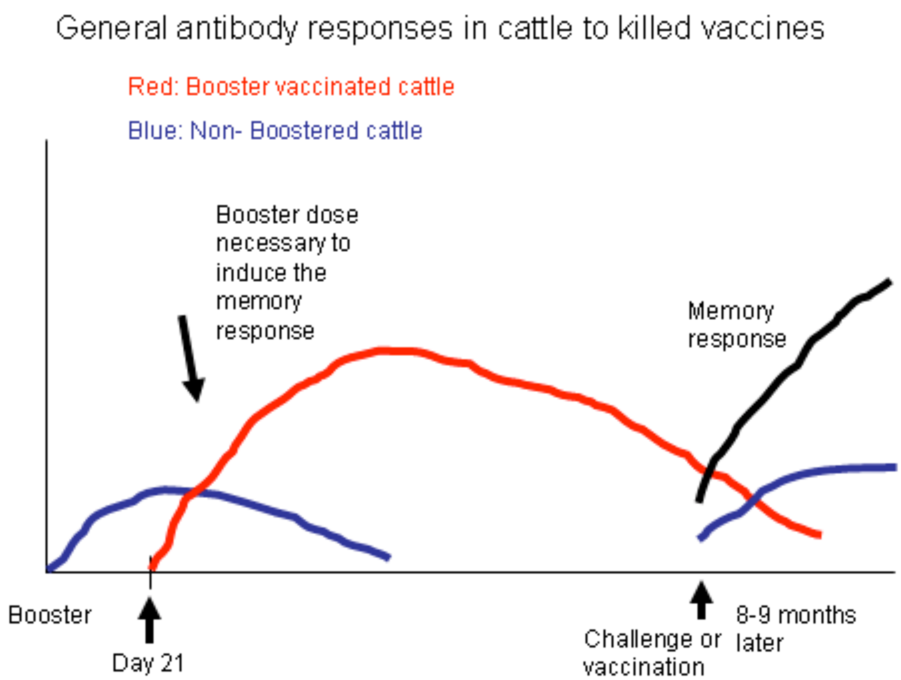
From a scientific basis, vaccination strategies for grass finishing operations do not differ significantly from vaccination strategies for grain fed cattle. The upside is that grass fed operations lend themselves to better biosecurity and less frequent and severe disease challenges which aid the effectiveness of any vaccination program. However because grass finished cattle are less confined and usually are rotationally grazed the aggravation factor and labor requirements to pull and treat cattle on grazing systems is usually greater. This somewhat alters the consequences of BRD because the additional labor costs magnify the production losses and treatment costs that are typically associated with BRD. Treating cattle with antimicrobials for respiratory disease may make them ineligible for natural or other branded market programs that they were intended for, resulting in loss of that market premium and loss of the additional investment in those animals to qualify for those premiums. Additionally the production robbing and carcass quality effects of BRD are well known and documented in multiple studies.

Vaccine Basics-

In general vaccines are designed to illicit an immune response in cattle that will provide some measure of protection from disease if an animal is infected with a disease causing agent. Some vaccines do this by stimulating production of antibodies, like vaccines for diseases caused by bacteria (Examples-blackleg vaccines, and *Mannhiemia haemolytica*). Some vaccines provide protection by stimulation of highly specialized cells that combat virally infected cells (Like IBR vaccines), and some protect by a combination of both (Like BVD and BRSV vaccines).

Vaccines generally exist as killed vaccines or bacterins or modified live vaccines (MLV). Bacterins and killed viral vaccines are made up of virus and bacteria that have been grown in the laboratory and killed and formulated with immunostimulants designed to create a favorable immune response. These vaccines are usually capable of producing an antibody response, and some can produce measurable cell mediated responses. These vaccines usually require a booster dose in 2 to 3 weeks to achieve a meaningful immune response. This second booster dose is critical to prime the immune response adequately for subsequent yearly vaccinations and to provide the protection they are designed to provide for natural disease challenge. The graph below demonstrates this concept. The blue lines indicate cattle that are given killed vaccines and are not boostered at the proper interval. The antibody response is not as good and there is not a significant increase in antibody response if the vaccine is given again 6 to 12 months later. The red line illustrates the antibody response if the vaccine is boostered at the proper interval. This provides higher antibody levels which last a longer time period. The black line represents the animal's response if they are exposed to the disease causing agent several months after vaccination. Because the immune system was properly stimulated with the booster dose the animal is capable of responding with an aggressive memory response which provides a quick response to the bacteria or virus, which provides more protection for the calf. Not giving the booster dose blunts or eliminates this capability to respond with the memory response and substantially limits the calf's ability to respond to a disease challenge.



Modified live viral vaccines are made of live viruses and thus tend to produce a more balanced and effective immune response addressing both cellular and antibody mediated immunity. They typically produce a more predictable and effective immune response than killed vaccines, and have proven their superior effectiveness in clinical trials. MLV vaccines are generally viral vaccines

With any vaccine regardless of type the protection does tend to diminish over time, therefore annual revaccination is necessary for complete protection, and depending on the agent revaccination more frequently may be required, as the duration of immune protection varies from vaccine to vaccine and from infectious agent to infectious agent. A good example of this is the duration of protection afforded by modified live BVD vaccine compared to the duration of protection offered by most leptospira bacterins. Because of the continued erosion of protection it is important to time vaccine administration to provide the most solid protection during the time period when you anticipate the most significant disease challenge. So logically for protection against respiratory disease you would want to time respiratory vaccines (IBR, BVD, BRSV, PI3, *Mannhiemia haemolytica*) to produce the most solid protection at weaning or prior to shipment. Although beyond the scope of this discussion it is useful to mention that typically reproductive vaccines (IBR, BVD, Leptospirosis, Vibrio) are most appropriately administered prior to cows 30 to 45 days prior to breeding to provide the best protection during early and mid pregnancy when a great number of infectious reproductive losses occur.

Application of Vaccine Basics into Vaccine Strategies

From the standpoint of effectiveness it is best to have the calf's immune system primed with the vaccine prior to expected disease challenge (Ellis 1996). For the purpose of feeder steers that typically means prior to weaning or prior to shipment. The optimum time to administer vaccines will depend on whether calves will be backgrounded or shipped straight off the cow at weaning. If calves are to be shipped at weaning, the vaccines should ideally be administered once on the cow and appropriately boostered 2 to 3 weeks prior to weaning. Realistically this is often difficult to accomplish, especially in large ranches so often the calves are vaccinated once on the cow and booster vaccinated either at weaning or immediately after shipment.

If calves are to be backgrounded on farm there is a great deal more flexibility in the decision. Calves can be vaccinated on the cow, and boostered prior to or at weaning, or the vaccinations can be delayed until weaning time and boostered 2 to 3 weeks later. As mentioned previously- modified live viral vaccines produce quicker more predictable responses in cattle, but there are label restriction on administering most MLV vaccines to pregnant cow or calves nursing pregnant cows unless those pregnant cows have been vaccinated with MLV vaccines within the previous 12 months. For that reason the vaccination strategies for calves may have to be modified according to the vaccination history of the cow herd. Consult with your veterinarian and read vaccine labels to determine which are suitable to administer to pregnant cows or calves nursing pregnant cows.

Once the calves are weaned and not nursing those pregnant cows modified live viral vaccines can be administered to any calf which simplifies utilization of MLV Vaccines at weaning and after. The chart below depicts in graphic form some times for vaccine intervention. Timing or vaccination represented by the black arrows would represent a vaccine strategy for a ranch that does not intend to background the calves on the ranch or for one that is experiencing respiratory disease in nursing calves or has a history of respiratory disease in the weaning pen. If the Mannhiemia vaccine is administered at the first calf working it would be advisable to administer another at weaning or 2-3 weeks prior to shipment. The red arrows would represent a ranch that does not work calves on the cows but weans and backgrounds the calves on the ranch. In this case it makes the most sense to administer vaccines at weaning and schedule a second handling 2 to 3 weeks later for the booster vaccination.

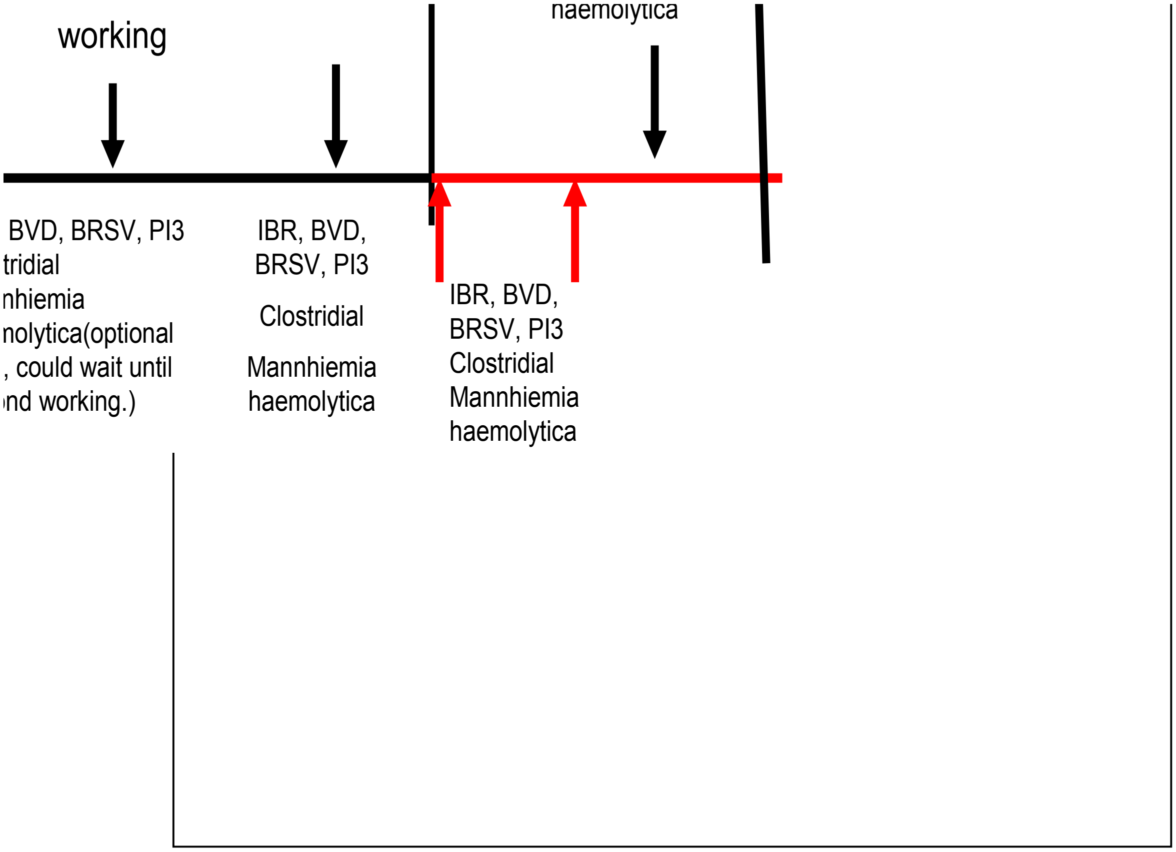


Chart represents classes of vaccine; consult with your veterinarian regarding appropriate vaccine choices and label restriction for pregnant cows.

Vaccination of calves on arrival with unknown origin and unknown vaccination history becomes more complicated and the vaccine results are much less predictable. These cattle are trying to mount an immune response to a natural disease challenge at the same time we are attempting to induce and artificial response with a vaccine. In some cases the race between natural disease and vaccine protection will be won by natural disease. Vaccination in these cases is not useless and in many instances satisfactory protection can be achieved if disease challenge is delayed, but recognize that this is the class of cattle that might result in disappointment in terms of vaccine protection. Modified live viral vaccines are more likely to provide quicker protection in these cases.

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Review of vaccine class effectiveness.

MLV vs. Killed viral vaccines- as mentioned earlier multiple studies are available to document the effectiveness of modified live viral vaccines as compared to killed viral vaccines is protection against respiratory disease, thus there is little disagreement that vaccination with MLV vaccines prior to shipment produces the best results in terms of reduced sickness and death loss. This fact is reflected in most recognized preconditioning programs requiring 2 doses of MLV vaccines prior to shipment.

MLV vaccines also provide quicker measurable protection than killed vaccines. In addition to providing quicker measurable protection in terms of antibodies and cellular immunity they are also capable of stimulating other classes of antiviral protection prior to the ability to measure significant increases in antibodies. In terms of protection booster doses of MLV vaccines is less critical, however many MLV vaccines carry a booster dose recommendation mainly to provide more adequate protection against BRSV, which often requires a booster dose to achieve the best protection, even thought it is a live component of most vaccines.

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Mannhiemia haemolytica-

Studies have shown that the best protection against *M haemolytica* occurs when cattle mount an immune response directed against specific components of the bacteria's cell wall (outer membrane proteins, capsular polysaccharide, iron regulated proteins), and against specific toxins produced by the bacteria (leukotoxin). Challenge studies have shown that cattle that develop immune responses to these important components are protected more completely. The vaccine response against leukotoxin is very important in conferring protections, thus this is an important factor to consider in selecting *Mannhiemia haemolytic* vaccines. As mentioned above it takes a period of several weeks to mount an effective immune response to protect against challenge, so vaccination prior to shipment for this particular organism is important to achieve the best protection.

Can J Vet Res 1998 Jul;62(3):178-82
Comparison of serologic and protective responses induced by two Pasteurella vaccines.Mosier DA, Panciera RJ, Rogers DP, Uhlich GA, Butine MD, Confer AW, Basaraba RJ

Vaccine 1996 Feb;14(2):147-54
Evaluation of three experimental subunit vaccines against pneumonic pasteurellosis in cattle. Sreevatsan S, Ames TR, Werdin RE, Yoo HS, Maheswaran SK

Mycoplasma bovis vaccines

Mycoplasma bovis has emerged in feedlots, stocker and backgrounding operations as a significant health concern in commingled light weight feeder cattle. Occasionally substantial M bovis health issues have occurred in relatively closed cow calf operations and in backgrounded ranch fresh feeder cattle. Formerly Mycoplasma bovis was regarded as an organism that occurred late in the respiratory disease process, but recent studies indicate that in is present in a vast majority of cattle early in the disease process and may be considered as one of the primary causes of BRD. Presently there is not much consensus on the effectiveness of Mycoplasma bovis vaccines in terms of protection against respiratory disease. Mycoplasma bovis has some biological attributes that makes formulating a vaccine challenging. This organism has a great capacity to change itself in ways that confuse the immune system and reduce the effectiveness of antibodies that are produced against it. Additionally studies have shown that control of Mycoplasma bovis in the animal may not be accomplished as well by antibodies as previously thought, making other components of the immune system more important. Vaccines available against Mycoplasma bovis have met with variable effectiveness in clinical trials and no large scale studies are available at present in the literature to document effectiveness. Some experimental vaccines however have shown promising results in limited studies they are not currently available for use. As with any vaccine success will depend upon administration prior to challenge, which will require substantial planning and administration prior to shipment.

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Behrens A, Poumarat F, Le Grand D, Heller M, Rosengarten R

J Immunol. 2004 Jun 1;172(11):6875-83. The upper and lower respiratory tracts differ in their requirement of IFN-gammaand IL-4 in controlling respiratory mycoplasma infection and disease.
Woolard MD, Hodge LM, Jones HP, Schoeb TR, Simecka JW.

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Vaccine handling and factors related to effectiveness

Modified live viral vaccines are more predictable and elicint quicker protection than killed viral vaccines. They do however have to be handled properly to maintain their effectiveness. For MLV vaccines to be effective the virus has to remain alive and capable of replicating in the animal to elicit an effective immune response. This is why most viral vaccines are shipped in a cake that has to be rehydrated. Once the vaccine is

reconstituted it needs to be used quickly, preferably within an hour, and within 30 minutes in exceptionally hot weather. The vaccine must be protected from sunlight.

Common disinfectants will easily kill MLV vaccines, so even trace amounts of disinfectants remaining in syringes will inactivate MLV vaccines and cause them to be ineffective. MLV syringes should never contact chemical disinfectants and should be marked clearly as MLV only and should be disinfected with boiling water only. MLV syringes should only be used to administer MLV vaccines, as other bacterins often contain formaldehyde which will inactivate MLV vaccines.

Bacterial vaccines or bacterins are already killed and as such are less susceptible to sunlight and heat issues. They should however be kept cool and care taken to avoid contamination of multidose vials. Some of the bacterial vaccines are produced with bacterial components containing bacterial endotoxins and other bacterial products. If vaccines are subjected to freezing, thawing, excessive heat or other mishandling it can elevate levels of free endotoxin which can have adverse consequences on cattle after administration. Multidose vials are also subject to contamination with other bacteria, so only a clean needle should be used to draw our doses of vaccine. A good rule of thumb is if a needle has been in a calf it should never go into a bottle of vaccine or other injectable product.

Most importantly vaccines are designed for and labeled for use in healthy well nourished adequately hydrated cattle. Cattle that are is less than optimal shape stand a chance of a reduced response to vaccination. Vaccination programs should be designed with the goal of addressing common disease conditions for which proven effective vaccines are available. Discuss vaccination protocols with your veterinarian to address local disease conditions and their recommendations that address timing, local issues and other disease control and biosecurity issues that are necessary for any vaccination program to succeed

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In today's animal agriculture various trends are present to potentially increase the prevalence of diseases in herds. Infectious, metabolic, and toxic diseases all can be important for consumer confidence and economic reasons. Infectious diseases often get the greatest emphasis for control, but there are also many other health issues that should concern animal producers. Beyond the most obvious bacterial and viral infectious diseases, grazing animals can be exposed to other health risks. These health risks can include varying exposure to parasites, toxic plants, metabolic disease, and environmental stresses. While many of these risks are similar to confined herds, there are some unique challenges and opportunities for grazing herds. This short paper will review some of these unique aspects of animal health while animals are on pasture. While it is impossible to explore all animal diseases in a short paper, the following proceedings will attempt to cover some of the current issues concerning animal health and grazing.

Overall animal welfare concerns are generally less in grazing systems. New well maintained barns can accomplish very good animal welfare, but often confinement in conditions that are not ideal, places animals in physiological stress (9). Certainly behavior, health and productivity, and disease morbidity can be used as indicators of overall animal welfare. Stress is difficult to define concisely, but the presence of stress can act to depress productivity and to promote physiological changes that may lead to disease. In that regard animals on well maintained grazing systems generally are subjected to less stress and often have a reduced incidence of diseases. This is frequently reflected in reduced veterinary medical costs, greater animal longevity, and reduced culling rates (21).

General Biosecurity Practices

As herd size increases and as herds are placed in more intensive management systems, be this in confinement or grazing, it is easier for infectious diseases to enter and spread through a herd. In this regard relatively small and stable herds with minimal herd additions and good animal comfort frequently have a lower prevalence of infectious disease. Such herds may have advantages in developing a biosecurity and biocontainment program. Herds that graze and manage their pastures well often have the additional advantage of placing their animals in environments that frequently have reduced pathogen loads. Direct contact between animals or between animals and contaminated secretions is generally the most effective manner to transfer pathogens. Animal spacing, improved air quality, and reduced direct contact are factors that reduce the risk of pathogen spread. While pastures and grazing can improve biosecurity, it is

important to remember that biosecurity risks are reduced and this is not the same as elimination of risk.

To begin a biosecurity plan, a review of risk factors present on a farm should be conducted. The most common biosecurity risk factor is the purchase of animals. New additions to the herd should be inspected carefully and screened for any infectious diseases. Some infectious diseases can be prevented through immunization or careful screening. Diseases with short incubation times and proven vaccines can be prevented in this manner. Unfortunately for many of the diseases of biosecurity concern immunization and screening can be difficult or ineffective.

Ideally new herd additions should be quarantined for four weeks. If animals cannot be isolated for the full time, at least an attempt to keep animals groups separated for one to two weeks. All animal discharges, manure, urine, and fetal fluids should be isolated from suspect animals. The quarantine should also involve separate air handling and separate feed and water troughs. In general, many acute diseases run their course in two to three weeks, and the use of an effective quarantine program can greatly reduce certain biosecurity hazards. Animals that become ill should be isolated from the herd as soon as is possible. This minimizes the chance that heavily shedding animals will contaminate other members of the herd. Stressed animals are at a greater risk of shedding or acquiring infectious agents. Maternity pens and areas for young, susceptible animals should be the cleanest and best maintained areas on a farm.

Other risk areas include; common equipment to feed and haul or scrape manure, clothing/boots, wildlife vectors, or stock trucks/ trailers that have not been adequately cleaned between herds. Common fence lines, shows and fairs are also possible contact areas. It is extremely important to reiterate that animals and animals' secretions of any nature generally provide the greatest risk for spreading disease. It is usually better to have younger animals in separate paddocks or allow the younger animals to have access to a paddock prior to older animals. This strategy can prove difficult with some management schemes, but will often reduce disease and parasite transmission.

If at all possible, manure should be spread on cropland and not pastures. If manure must be spread on fields that will be grazed, it is helpful to take a cutting of hay from the field first. Finally, approximately six months should be allowed to pass after manure is applied before grazing.

Grazing animals have some distinct advantages in animal comfort and welfare versus many confinement-housing systems. However, the biosecurity risks can be equal to or greater in the grazing environment vs. the herd in confinement. In most cases management is the key. Better population density in grazing herds and a clean environment, such as on well-maintained pastures, can reduce infectious diseases during the grazing season. If producers would adopt a biosecurity plan for herd additions and actively screen those additions, much economic and animal suffering could be avoided. Further if a biocontainment plan would be instituted to control diseases already on the farm, the overall health of the herd would improve and the market share of animal and animal products could be increased. For specific biosecurity recommendations please see presentation by Dr. John Comerford.

Salmonella

Salmonella spp. are Gram-negative bacteria that are found in a wide variety of vertebrate animals. There are over 2000 serotypes of Salmonella. Some are adapted to specific hosts and while others can be found in a broader range of animal species. Salmonella can survive at pH's between 4 and 8 and can grow at temperatures between 8 and 45°C. Salmonella can survive for months in soil, manure, or in contaminated water (2, 14). Composting will kill or significantly reduce salmonella in manure. The most important aspect of decontamination is to remove all manure and organic material (bedding, chaff, dust, and old feed). On hard surfaces, after the manure is removed, compounds such as chlorines, iodines, quaternary ammoniums, or phenols can be effective disinfectants. However, as Salmonella can be spread throughout the environment and be found in asymptomatic carrier animals, wildlife or wildfowl. Elimination of all sources of the bacteria can be difficult. Diligence and a monitoring system should be implemented.

Some strains contain virulence factors that make those strains significantly more likely to cause disease. In animals, the disease can manifest itself as peracute infection with enteritis and septicemia, this is frequently fatal. Acute enteritis is most commonly seen in adult cattle. Here animals experience fever and diarrhea. The clinical signs can be severe and some animals may die. In chronic cases diarrhea may persist with or without diarrhea. Most of these animals survive but may be slow to recover and be unthrifty. Finally some animals carry the bacteria and are perfectly healthy; however, they may shed the bacteria periodically in their feces.

In the face of an outbreak, treatment protocols vary and should be under the direction of the herd veterinarian. The veterinarian should be consulted as soon as possible when animals show signs of fever and protracted diarrhea. Animals with diarrhea and fever should be isolated from herd mates as soon as possible. Cultures should be submitted to a diagnostic laboratory for identification and an anbiogram. Finally excellent sanitary procedures should be practiced to prevent the infection from spreading between animals groups.

Control measures for Salmonella include the following. Quarantine and isolate new herd additions or sick animals. Do not use the same pen as a maternity pen and a sick cow/isolation pen. Control rodent and bird populations. Do not allow rendering trucks or contract animal haulers to have access to areas where feed is mixed or stored. Consult with feed companies to ensure that they screen grains and concentrates for Salmonella. Spread manure on cropland and not on pastures. If manure must be spread on pastures, do not graze animals on that pasture for six months (2). Fecal cultures

should be performed on individual or pooled manure samples to screen for Salmonella prior to purchasing herd additions. Currently only killed bacteria vaccines are available in the U.S. Results on these bacterins and core antigen vaccines (J-5®, J

Vac®, Endovac Bovi®, SRP®), or autogenous vaccines have given mixed results. In the face of an outbreak or following exposure the use of vaccines can help and will not hurt. As most Salmonella are zoonotic diseases for people, extreme care should be taken to prevent infection by the farm owners/ workers or the public via the purchase of animal products.

®Pfizer-Exton, PA.
® Merial - Iselin, NJ
®Immvac - Columbia, MO
®AgriLabs-St. Joseph, MO-

Paratuberculosis-Johne's Disease

Paratuberculosis is commonly known as Johne's disease. This chronic wasting disease primarily affects ruminants. The disease is seen most often in cattle, goats, and sheep. The bacterium responsible for the disease is *Mycobacterium avium* subspecies *paratuberculosis*. It is an obligate intracellular parasite and lives in the macrophage of the host (5).

Typically the animal is infected at a very early age. The dose to infect a young animal is inversely related to the age of the animal. That is a very few organisms can successfully infect an animal in the first few days of life, while it may take massive numbers (billions) to overcome the immune system of an adult animal. The bacterium is usually picked up first by the macrophages of the ileum and occasionally the tonsils. The infected macrophages then migrate by the lymphatic system to regional lymph nodes. The infected animal often does not show any outward clinical or detectable immune signs until late in the disease process, often years after the initial infection. Dissemination throughout the body may occur very late in the infection and is generally seen at or close to the time clinical signs of the disease become obvious.

In cattle the classical clinical signs are non-responsive diarrhea, absence of fever, good appetite, and weight loss. Currently there is no practical way to treat infected animals. Long-term therapy with drugs used to treat humans infected with tuberculosis can improve clinical signs and arrest the infection. Such treatments have only proved practical in a few unusual university or experimental situations. In general Johne's should be considered a fatal disease of any infected ruminant.

The Gold Standard for diagnosis is the culture of the organism from the feces of infected animals. Culture is time consuming (up to 16 weeks to declare a culture negative in solid media and 30 days for liquid media) and requires specialized culture medium. Strain differences exist with the bacteria, with cattle strains being relatively easier to grow than other strains. At this time bacterial strains that usually infect sheep cannot be grown in most laboratories. Recent work in Australia reports successful culture of the sheep strains (6, 7). Other techniques to diagnosis the disease include finding acid-fast bacteria in the tissue of the small intestine or lymph nodes. New

molecular diagnosistic techniques such as PCR can identify the bacteria in tissues, milk, or manure.

Due to the nature of the infection and the type of immune response paratuberculosis produces, there is no full proof test at this time to predict which animals are infected but subclinical and early in the disease process. The best method of dealing with Johne's is to control the disease if it is on the farm, or to take appropriate biosecurity measures to prevent it from entering the herd.

The addition of untested animals from herds of unknown origin and Johne's status is the most frequent method that Johne's is introduced onto a farm. As much as possible herds that are negative should remain closed and use strict biosecurity measures to stay Johne's free. New genetic material can be added to the herd via artificial insemination or embryo transfer. If new animals must be added, herd additions should only come from herds or flocks with a test negative status and a history dating back several years of no signs of Johne's infection.

Since the very young are the most susceptible to infection, great precautions must be taken to ensure that the newborns and very young animals are prevented from eating or drinking milk, manure, or feed that might contain the bacteria. Very strict hygiene must be practiced in the maternity area and areas that house youngstock. In general it is wise to sell high test positive animals as soon as it is possible. In some herds due to economic constraints, clinically normal but test positive animals need to be maintained in the herd. In these cases additional precautions need to be taken.

Small amounts of manure from infected animals can contain billions of viable organisms. For this reason, equipment that is used to haul manure must not be used to feed young stock. The bacteria can remain infective in manure, soil, and sediment at the bottom of ponds for well over a year. Manure should not be spread on pastures. Manure can be spread on crop ground, but care should be taken to ensure that erosion does not wash manure and bacteria into water supplies. In grazing herds youngstock should have separate pastures. Ideally all young animals (12 months in cattle) (5, 6) should be in pastures that are in separate rotations that do not include any adult animals during the grazing season.

In general many diseases of young cattle are picked up via the fecal-oral route. This is especially true for some of the common diarrhea diseases that affect very young calves. It is beyond the scope of this paper to review all of these diseases, but suffice it to say that most diarrhea problems in the first days to first few weeks are caused by various strains of E. coli. Animal density and exposure tends to increase these problems as the calving season progresses. A cost effective strategy to minimize these diseases has been advocated as the Nebraska University *Sandhills Calving System* (25). In this system calving areas are controlled to minimize the risk that very young calves are exposed to bacteria and viruses from calves born earlier in the season. As groups of cattle calve they remain in that paddock for a time, while other later calving animals are moved to new clean calving paddocks. This system has proven to be very cost effective for producers and greatly reduces the incidence of scours in calves. For additional information readers are referred to the Nebraska University web site for more details (http://www.extension.unl.edu/farm_ranch.htm).

Clostridial Myonecrosis

Clostridial myonecrosis is a term used to describe a group of acute diseases caused by anaerobic bacteria, which chiefly affect the skeletal muscles. These diseases are characterized by a very rapid course, fever, toxemia, and a high mortality. Mixed infections can occur. The signs may be similar for many of the bacterial in the Clostridium family.

Early in the clinical course affected animals are febrile, anorexic, and often lame. The disease is so rapid that affected animals are usually found dead. Most often the muscles of the limbs and trunk are involved. Initially the skin over the muscles is hot and discolored. This quickly progresses to become cool and insensitive; gas (crepitus) may be detected under the skin. If a wound is present any draining fluid will be dark and blood tinged and malodorous. Animals frequently become profoundly weak and death usually occurs within 12-24 hours. A diagnosis is commonly based on gross pathology and history.

The bacterial spores are common in the environment and may be found in the intestinal track of perfectly healthy animals. The exact reason that some animals become infected is not clearly understood. Any break in the skin (e.g., a wound, needle injection, or deep bruise) may be sufficient to create an environment suitable for the growth of the organism in tissue. Sudden feed changes and the rumen acidosis syndrome is also associated with a higher incidence of the disease. In pastures or areas where the disease has been present in the past, a much greater likelihood or recurrence is possible.

If the disease is identified very early in its development, it may be possible to treat the animals with debridement and massive antibiotic therapy. Occasionally specific antitoxins may be employed. These can be extremely expensive. Other supportive therapy for shock may be beneficial. However, it is important to remember that the mortality associated with the Clostridia diseases can approach100% with or without treatment. Any animals that die on the premise from one of these diseases should be carefully disposed of by deep burial, burning, composting and removal off site, or removal. Body fluids and tissues may contain millions of spores, which can further contaminate the environment.

Many vaccines can be purchased for the prevention of the disease. Commonly the vaccines contain antigens and toxoids from the most common species, including *C chauvoei*, *C septicum*, *C novyi*, *C sordelli*, and *C perfringens*. Diseases associated with other members of the Clostridium family such as tetanus and type A perfringens require other vaccines or may not yet have effective vaccines. Protection to the various vaccines varies and careful attention to label administration instructions and claims is important. Livestock should be protected prior to any management or handling procedures that could trigger one of these diseases (e.g., castration, dehorning, major feed changes).

Mastitis

Lactating animals on pasture are generally considered to have a lower incidence of mastitis than animals in confinement. While this is true in many cases, there can be circumstances where risk of mastitis is greater in grazing situations. In general the environment provided and hygiene of animals on well-maintained pastures is usually superior to confinement situations. Animals on pasture in good weather generally have a lower incidence of mastitis due to environmental bacteria (e.g., fecal Streptococcus bacteria and E. coli). However, during inclement weather the rate of new infections due to environmental bacterial can exceed the rate in confinement. Walkways and paddocks that become deep with mud should be avoided.

It has been known for some time that as animals congregate to avoid flies or be protected from the sun, that such areas can become mud holes. High animal densities greatly contribute to environmental mastitis, especially due to E. coli. Common use areas around waterers or outdoor feed bunks can also be areas where environmental bacteria multiple and contribute to contamination of the udder and teats. Drainage, fencing and/or rotation to avoid these areas are well-recognized management procedures and should be practiced more intensely.

Lameness

A major concern of extensively managed animals is lameness. Several surveys have placed the incidence of lameness of herds on pasture at a mean herd incidence of 7% (range 0-31%). Other studies have put lameness at total annual rates as high as 60% of herds (8). A major contributor to overall prevalence of lameness is the condition of walkways to and from paddocks. Bruising and damage of hoof and interdigital space by stones, sharp objects, or crowding had the greatest influence on new cases of lameness. Trauma can contribute much to the number and extend of lameness exhibited by cattle. Trauma to the sole or interdigital area can reduce the integrity of the skin or sole making the soft tissue more susceptible to infection. Good maintenance of walkways/alleys where animals step off concrete and onto dirt is especially challenging. These areas typically become mud/manure holes where animals can step on rocks buried beneath the surface. These moist areas contain urine and manure and become breeding grounds for bacteria that can cause infections.

Digital Dermatitis (Hairy Heel Warts)

Digital dermatitis is an infectious disease of the hooves of all breeds of cattle. It is sometimes called hairy heel warts, strawberry heel, or digital warts. Most researchers believe the bacteria to be a Treponema although there is some controversy as to the exact etiology.

In moist conditions the disease can spread very rapidly through the herd. The problem seems to be especially acute in free stall barns, but has been reported in feed lots and pastures if they contain muddy sections. The earliest lesion is a reddened circular area just above the interdigital cleft on the plantar side of the hoof (on the bulbs of the hoof at hair level on the heel). Often the hair seems elongated and erect. Gradually the hair is lost and a moist reddened lesion appears with a surface appearance that looks like terry cloth. The lesion at this stage bleeds easily and is extremely painful for the animal. In later stages the lesion may develop a blackened appearance with long hair like growths from the skin (12, 19). Occasionally the lesion will be seen on the front of the hoof at the juncture of the claws at the coronary band.

Animals may be so painful with this lesion that the heel becomes overgrown and the toe of the hoof worn nearly to the sensitive tissue by abnormal wear and use of the limb. Initial infections occur most often in young animals. Most animals appear to develop a level of immunity and may not show as dramatic clinical signs after the initial infection. However, some animals develop repeated bouts of painful clinical lameness.

Treatment is usually accomplished via footbaths or hoof spraying programs. Walk through foot baths can be effective, but must be well maintained to avoid manure contamination and inactivation of the effective ingredients. 5% formalin, 0.1% to 0.4% tetracycline, 0.01% lincomycin, or acidified ionized copper footbaths can be used several days in a row and provide good herd control and treatment. Hand held or backpack sprayers have been used with 25mg/ml tetracycline or 1 mg/ml lincomycin to spray the affected hooves in large herds with very good success (9, 12).

This disease can be a great economic drain on the herd due to its widespread prevalence and great effect on productivity due to losses associated with decreased dry matter intake, weight loss, and milk depression. Prevention should be an important aspect of the biosecurity program of all cattlemen. The organism can easily be transported onto the farm by newly purchased animals, the manure off cattle trucks, waste/manure off rendering trucks, or unsanitized hoof trimming equipment. Producers should insist that hoof trimmers have clean and sanitized equipment before they enter the farm. If possible producers should use their own trucks and trailers. If different age groups of animals need to be transported on the farm or if private contract haulers must move cattle, trucks and trailers should be cleaned and power washed between groups of animals. Pick up locations for renders should be a short but convenient distance away from animal housing and feeding areas.

Newly purchase herd additions should have visual inspection of their hooves prior to entering the barn. New animals should have their hooves sprayed off with water and then be treated with a medicated hoof spray or walk thorough a medicated hoof bath prior to entering the herd. If possible the new additions should be quarantined and separated from the main herd for 3-4 weeks and signs of lameness monitored during this time. Aggressive monitoring and treatment can prevent the disease from contaminating the environment and infecting the entire herd. In grazing herds, good pasture management often controls or eliminates the disease during the grazing months. If pastures are reasonably dry, the drying action of the pasture and the cleaning action of the grass will prevent most new infections.

The bacteria can live in moist soil or manure for several months and will survive outdoors in damp conditions throughout the grazing season. Common walkways can be a source of transfer and infection between groups. Alleys that are not properly

maintained can harbor the organism in moist areas. Low spots and areas that are heavily contaminated with manure should be eliminated. Individual animals that develop signs should be segregated and treated promptly to minimize spread of the disease.

Foot Rot (Interdigital Necrobacillosis)

Foot rot is the infection of the skin and soft tissues between the claws of ruminants, especially cattle, sheep, and goats. The disease seems to be most prevalent in cattle. The infection is caused by the co-infection of several bacteria. Most cases involve *Fusobacterium necrophorum* and *Bacteroides nodosus*. Animals are predisposed to infection by moist conditions and rough stony land or plant stubble than can injure the interdigital skin. Once the skin is injured the bacteria infect the damaged tissue and produce toxins, which can lead to damage of the hoof and underlying soft and bony tissue (9).

Affected animals typically become acutely lame, with redness and swelling in the infected hoof. Swelling can extend to the fetlock and in severe cases the skin and infected soft tissue can become necrotic and foul smelling. Treatment normally involves high doses of antibiotics for an extended period and local cleaning or debridement of the infected tissue. In the Northeastern regions of the U.S. there have been sporadic reports of foot rot that seems to be resistant to most common antibiotic treatment protocols (Super Foot Rot) (9). Due to the difficulty in treating this form of foot rot, biosecurity practice should be instituted to prevent the importation and the spread of these antibiotic resistant strains.

Newly purchased animals, manure from stock trucks, or improperly cleaned hoof trimming equipment are the most frequent high-risk area. Producers should insist on clean and sanitized trucks, as well as clean and sanitized hoof trimming equipment. Herd additions should have their hooves sprayed off with water prior to entering the barn. A clean walk through footbath or sprayer should then be used to treat and sanitize the hooves. If possible animals should be isolated for several weeks and monitored for signs of infectious disease prior to mixing with the resident herd. Affected animals should be treated as soon as possible after clinical signs are noted. Infected animals should be prevented from contaminating walkways or housing areas.

Manure laden, moist skin predisposes animals to foot rot. In pastures, walkways must be well maintained to prevent moist areas. Wet swampy areas of pastures should be fenced off during rainy weather. Paths should be maintained to keep them free of sharp stones, rough gravel, and other debris. The ground around feeders and waters should be built up to allow water to drain away.

Protozoan Diseases

Neosporosis (Protozoan abortion)

Neosporosis is a disease caused by the protozoan parasite *Neospora caninum*. The definitive hosts are canines (in these species the sexual reproduction of the parasite occurs). If a susceptible canine eats the flesh of a prey animal that has arrested cysts in its tissues, the parasite will grow in the intestinal tract of the canine. After several intestinal generations the protozoan will produce the final stage of the life cycle in the dog, an egg like oocyst. In canines infective oocysts are passed into the environment in their feces. Cattle, sheep, goats, deer serve as intermediate hosts. In the case of livestock, the ruminant eats an infective oocyst, which contains 4 sporozooites (13). The sporozooites invade the host through the intestinal tract and cause a systemic (whole body) infection. In nearly all cases there are few if any signs and the protozoa becomes latent and arrested in the tissues. The process by which the organism passes from prey to carnivore to a different prey animal is called horizontal transmission.

If the animal is pregnant at the time the infection is spreading throughout the body or if a latent infection becomes activated during pregnancy, then a whole array of clinical disease can occur in the fetus. In many cases, fetal death and mid gestation abortion will occur. Some calves will be born with severe congenital brain or nervous system damage. Other calves will be born with partial paralysis or limb ataxia. Most calves will be mildly infected but normal at birth and appear to grow normally. Recent research indicates that in nearly 80% of the cases an infected dam will pass the infection onto her offspring (16). The passage of the infective agent from generation to generation without the definitive host is called vertical transmission.

Abortion is the most costly and noticeable result of a Neospora infection. In cases where many susceptible animals are exposed by a feed source, or if a wide spread immuno-suppressive agent enters the farm such as BVD, then a devastating abortion storm may occur. First calf heifers have a significantly higher risk for abortion if they are infected. Subsequent gestations by infected animals have a risk for abortion slightly above background for the herd. Some animals repeatedly abort their calves; therefore, animals infected with Neospora maybe culled prematurely.

Serology tests, such as ELISA, can be used to screen animals that have been exposed to the protozoa. Animals that are positive on ELISA are a risk to spread the disease to their offspring. Negative animals on a positive farm are at risk to pick up a new infection and if exposed may be part of an abortion storm. Recently a Neospora vaccine has entered the livestock market (NeoGuard® Intervet). Efficacy is still being evaluated. It could be speculated that in truly negative animals the vaccine probably will help to prevent the initial infection and may well help to reduce abortions in naïve animals. In already infected animals it could be speculated that the vaccine does no harm, but may be less beneficial. Careful review of the herd situation by a veterinarian should be considered before instituting a vaccination plan. Several good biosecurity practices can help to minimize the spread of Neospora in cattle herds.

First, if the herd has been screened and is free of Neospora, herd additions should be negative as well. Most diagnostic laboratories are performing an ELISA test that has a high predictive value for identifying animals that have been exposed to Neospora. If there is no history of vaccination, then any animal positive on an ELISA test should be considered as having a subclinical latent infection. If the herd or animals are truly negative but at risk for exposure, then the use of the Neospora vaccine is probably

justified. In herds that harbor the parasite, producers could use the ELISA test to identify all the latent subclinically infected animals. The producer would want to develop a cost effective strategy to gradually reduce/remove as many of the latent carriers as is possible. Youngstock of any positive animal should be screened to determine which if any were infected in utero.
Aborted fetuses, dead calves, and placentas should be discarded, buried, composed, or rendered in such a way that dogs or wild canines cannot eat the tissue. Pups would be infected in this manner and then spread the infection in the environment. This could be especially important in pasture situations where dog, fox, or coyote feces could contaminate a pasture. In all cases, dog manure must be prevented from entering the ration of livestock. This is especially important in areas where trenches are used to store feeds for TMR's.

Coccidia and Cryptosporidia

The intestinal protozoan parasites are primarily a problem in very young animals and are frequently of greater concern in confinement systems. However, fecal-oral contamination can occur on pastures. Most infections occur in animals prior to or shortly after weaning. With age and exposure most livestock become resistant to infections from intestinal protozoa. Any age can become infected if immunity is depressed or absent. The oocysts (eggs) of coccidia and especially cryptosporidia are fairly hardy and can survive in the environment for many months. Intestinal infections with coccidia can be controlled with ionophores or approved oral sulfa pharmaceuticals. There are no approved cost effective treatments for cryptosporidia.

Parasites

Nematodes-Stomach Worms-Round Worms

Internal parasites can be divided into two large groups, the nematodes (round, stomach or intestinal worms) and the protozoa (coccidia and cryptosporidia). The intestinal protozoa were discussed in the previous section. Nematode infections are the more familiar type of parasite infection. Some of the more common species are Osteragia, Trichostrongylus, Haemochonchus, Cooperia, and Nematodirus. Serious concern is emerging regarding resistance to common therapeutics and pharmaceuticals. It is extremely important that cattle producers develop a sound systematic approach to parasite control. Indiscriminate and untimely use of products will over time lead to increased parasite resistance. The development of resistant strains can become a significant economic strain on producers and an emerging animal health and care issue. Control and production issues surrounding internal parasites will be covered in more detail by previous speakers. Readers are referred to the presentation by Dr. Louis Gasbarre.

External Parasites-Flies and Biting and Sucking Insects

It has been estimated that flies can reduce the feed efficiency of beef animals on pasture by 10% to 15%. In nearly all circumstances the use of an integrated approach to control is the most effective and utilizes the least amount to chemicals. For additional information on external parasites, readers are referred to the presentation by Dr. Charles Pitts.

Thermal Stress

Effects of High Environmental Temperatures

The combined effects of high temperatures, high relative humidity, and solar radiation can have profound effects on production, reproduction, and animal health (1, 18). When animals are exposed to environmental conditions above their thermoneutral (comfort) zone they begin to exhibit some signs of heat stress. As heat stress increases animals respond in several ways: reduced feed intake, increased water intake, changed metabolic rate, increased evaporative water loss, increased respiration, altered hormonal levels, and increased body temperatures (3). These changes if not managed properly can result in dramatic reductions in milk production, declines in feed intake, very poor rates of gain, and much reduced fertility.

Heat stress can be especially deleterious to pregnant animals. Changes in endocrine levels can produce reduced birth weights, increased risk of retained placenta, and reduced immunoglobulins in colostrum. Pregnant animals that do not eat well have a much greater risk of developing diseases such as ketosis and displaced abomasums (18). Post partum cattle also suffer great reductions in reproductive efficiency.

Reproductive performance is dramatically lowered during heat stress. Conception rate is reduced by changes in the endocrine levels and greatly depressed estrus expression (10, 17, 18). These levels of inefficiency are further compounded by reductions in embryo survival and development (17). Cows especially need protection from heat stress during estrus and for at minimum of 7 days after breeding.

In many cases the most cost effective method of reducing heat stress is to provide ample shade. Tress can be excellent sources of shade but the tendency of animals to cluster under trees provides problems with moisture and flies, as mud holes tend to develop. If portable shades are used they can be moved to prevent destruction of pasture grass and wallow formation. Florida research indicates that cows need 4.2 to 5.6 m2 of shade per animal (4).

In this region cold stress is rarely a problem for livestock as long as adequate food, water, and protection from wind are provided. A key factor commonly missed in the management of pregnant animals during cold stress is the need for additional feed, especially fermentable nutrients capable of increasing energy. Rations that work well under routine temperatures may not provide sufficient nutrients when additional reserves are needed to provide body heat. The prevalence of metabolic diseases such as ketosis and pregnancy toxemia can be exacerbated by failure to reformulate rations for heavily pregnant animals under prolonged cold stress.

Metabolic and Ruminal Disorders

Bloat

Bloat is the abnormal distension of the rumen with gas. This may be free gas bloat or frothy bloat. Frothy bloat involves the development of a stable froth by the mixing of gas and soluble plant products and proteins. This type of bloat can be an individual animal or herd wide problem. Frothy bloat is commonly associated with lush legume or winter wheat pastures. It appears that both animal and plant factors are important as not all animals are uniformly susceptible even on the same pasture. Clovers and alfalfa plants that are very lush and in their rapid growth phase are most commonly associated with frothy bloat. Occasionally winter wheat pastures can cause herd wide problems with frothy bloat.

Acute bloat is life threatening and whenever possible relief from the pressure should be attempted via a stomach tube first. If no or insufficient pressure can be relieved by a stomach tube it can be necessary to use a stab type trochar or screw type trochar in the left paralumbar fossa (behind the ribs where the rumen is bulging). This frequently relieves the pressure but may be complicated by infection around the site. In some cases of frothy bloat simply using the trochar may not be sufficient to relieve the bloat and additional medication may be needed. Proloxalene® (44mg/kg orally) is the most common therapeutic for frothy bloat. Vegetable oils or fats can be helpful as well.

For prevention, animals should be introduced to new or very lush pastures gradually. If possible some dry hay should be offered to cattle prior to turn out on these types of pastures. Proloxalene can be offered as a lick block and adding an ionophore to a portion of the grain ration can also reduce the incidence of frothy bloat.

Traumatic Reticuloperitonitis (hardware disease)

Hardware disease is a fairly common disease of cattle and rarely seen in small ruminants. Metal, especially old pieces of wire can be accidentally ingested by cattle on pasture. If forage is limited on pasture cattle will often graze the areas immediately adjacent to fences. In many areas fences are at least in part made of old barb wire or woven wire. It is very easy for pieces of this old fence to be broken and allow pieces of wire to be found on the ground along the fence row. Cattle are not very careful eaters and can pick up wire or other metal objects if they are forced to eat in areas that may be contaminated. Cattle with hardware disease often go off feed, may have a low grade fever, and have very slow rumen contractions. Typically they lose weight and make very little milk.

Toxicology

Poisonous Plants

Many plants contain potentially poisonous substances which may be toxic to livestock if consumed. Several general characteristics are common to plant poisonings.

Plant Toxins

Nearly all plant toxins are products of the plants metabolism: and therefore, may not be necessary for plant growth. Many toxins have a strong or bitter taste, or induce a strong unpleasant reaction in the foraging animal (salivation, vomition, and diarrhea). This may be a protective mechanism to prevent the plant from being consumed. Plant toxicants vary widely in structure. Very different plant species may have similar toxic properties. Therefore very different plants may produce similar looking poisoning signs in the animal.

Factors Contributing to Plant-Related Toxicosis

Undernourishment, starvation, or overgrazing encourages animals to consume plant species that they may normally avoid. This may be especially common in early spring, late fall, or during drought conditions when forages may be scarce. Adverse climatic conditions, such as drought or frost may increase the toxic properties in the plant. Agricultural practices, such as fertilizers or herbicides may increase the potential for poisoning. More modern harvesting techniques may add toxic plants to forage. Green chop or ensiling practices may chop and mix toxic plants in a larger volume of good forages and Ahide@ the offending plants from livestock. Likewise seeds or toxins may be ground, added or disguised in grain or concentrate mixes. Other animal factors that may increase the potential for poisoning include: nutrient deficiencies, such as salt hunger which leads to animals consuming unusual plants, dirt, etc. Placing hungry or thirsty animals in a new location where they may over consume unsafe or contaminated forages or water. Confined animals that are well fed may become bored and consume toxic plants along a fence row due to curiosity.

Recognizing Plant Poisoning

A key skill to develop is the ability to recognize and identify common poisonous plants. Plant identification manuals, identification charts or photos are very useful in alerting the producer to potential problem plants. Extension agents, botanists, herbalists can be contacted and provide much information about unknown or suspect plant species. Many plant poisonings are strongly influenced by season or climate. Knowledge of the growing season or climatic changes that may produce toxic accumulations can be essential in avoiding toxicosis. The signs and time frame for suspected toxicosis can vary greatly between animal species, sex, and age even when a known exposure has occurred. Knowledge of the disease signs produced by the toxin, animal species involved and management history can be essential in determining if, when , or what toxin may be present. Finally, some estimation of the quantity of plant material consumed can be crucial in the diagnosis of a plant poisoning. This is especially important as some plant toxins can be suddenly fatal in very minute quantities, while in well balanced diets other toxins can tolerated for long periods at reasonably high levels. Several web sites are listed (www.ansci.cornell.edu/plants/ Http://vet.purdue.edu/depts/addl/toxic www.library.uiuc.edu/vex/toxic/into.html. Http://cal.vet.upenn.edu/poison/index.html. Http://res.agr.cal.drd/poisonpl/) For specific plants and potential for poisoning in different regions, readers are encouraged to consult local experts.

Nitrates, Nitrites, and Urea

Nitrates (NO_3) and nitrites (NO_2) can accumulate in plants under certain conditions (such as drought or over fertilization) and poisonings can occur acutely or chronically. Nitrate is more common and is less toxic than nitrite. Nitrite can be converted from nitrate and nitrite is readily absorbed by the blood and combines with hemoglobin. The bound hemoglobin can not carry oxygen and that produces the majority of the toxic effects of the nitrogen compounds. It is important for livestock producers to understand that levels of nitrogen containing products are additive from all feed and water sources. Nitrogen levels from all sources must be considered additive and therefore you have to account for all inputs to ensure that levels of nitrogen do not exceed toxic levels. Many ruminant animals can handle a fairly substantial load of nitrogen in the feed (urea or other non-protein nitrogen sources) if the rumen organisms have time to adapt to the available nitrogen. If high levels or secondary sources are suddenly added problems can occur acutely. A problem that has been seen many times in grazing herds is the addition of urea in molasses blocks or licks. These products can be perfectly fine if consumed at normal levels. On occasion animals may eat more than is recommended and develop sudden even fatal urea (ammonia) toxicosis. This can also occur if animals have been adapted to the product and then the product is unavailable for a few days. Following reintroduction, even the levels that were fine just a few days previous may now be toxic. Feeds containing higher levels of nitrates than normal or non-protein nitrogen sources can be used effectively in cattle and can be a cost effective way to provide a nitrogen source for microbial protein. They must however be added to the diet of ruminants slowly (gradually increased to an acceptable maximum level over a couple of weeks) and the total consumption of these products from all sources monitored.

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Biosecurity for the Farm

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Biosecurity

Farm biosecurity is an overall process of:

1. Awareness
2. Education
3. Evaluation
4. Management

The importance of farm biosecurity has never been greater, and no farm is immune from potential disease. Animal agriculture is a segmented industry-

- Cow-calf numbers steady to increasing
  - ► Number of farms stable
  - ► Mostly small operations (<50 head)
- Increasing intensity in feedlots
  - ► Fewer feedlots with more animals

These facts incur special opportunities and challenges to every beef producer.

Whole Farm Evaluation

The prevailing idea with beef producers is that disease on their farm came from somebody else's cattle. While that may be true in many cases, there is also a high potential that farmers brought disease to their own farm.

Disease transmission is:

1. Bidirectional. Every biosecurity evaluation of the farm should include the whole farm. It is just as important to recognize and manage what is leaving the farm as it is to recognize and manage what is coming on the farm. These factors include:
   a. Vehicle traffic: Where has that feed truck been? Where has your truck been?
   b. Human traffic: Did your son's friend walk through the barn before he came to the birthday party at your house? Where have you been today?

c. Water runoff: What potentially went in the creek from your farm? What potentially went in the creek from all of your neighbors?
d. Wind transmission: What did you and your neighbor send with the dust that flew up the other day?

2. Transmitted in the air: aerosol transmission from animal to animal, people to animal, and animal to people
3. Direct contact: mucous membranes, open wounds, blood, saliva, nose-to-nose, rubbing, or biting
4. Reproductive
5. Fomite (inanimate objects): gates, fences, trucks, feeders
6. Oral: eating or drinking contaminates
7. Vectors: flies, mosquitoes
8. Zoonotic: diseases that are spread from animals to humans

Steps to insure biosecurity

1. Know there is a risk

   The notion that "we have always done it this way" or "we already had it here" will be of no help because there are new and emerging diseases and variants of old diseases constantly. The value of risk identification and management is the value that may be lost to the farm by disease outbreaks. Prevention is the cheapest form of control.

2. Assess the potential risk from all sources of disease transmission

   Animals must be exposed to disease to become sick, so evaluate all forms of disease transmission for potential contamination.

3. Manage the risk

   Objectively identify the challenges to biosecurity on the farm. Design a management plan that is workable and effective by prioritizing the disease issues that are identified. Focus on the most susceptible animals like neonates and those under the most stress. Identify the prevalent sources of transmission like bulls and feeders. Keep records of disease incidence, prevention, and treatment with good animal identification. Have laboratory necropsy performed on animals that die from unknown causes.

Disease risk cannot be eliminated, but it can be managed. Protection of the farm from outside sources of disease from any source (up to and including terrorism) should become a part of total farm management. Effective control steps, preventive practices, and good records are both a source of invaluable information to the farm and can be protection for the farm in a localized, general disease outbreak. It pays to prevent disease!

Grass-Fed Beef in the Human Diet: I. Historical and Evolutionary Significance

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Historical Considerations: Grass Fed Beef

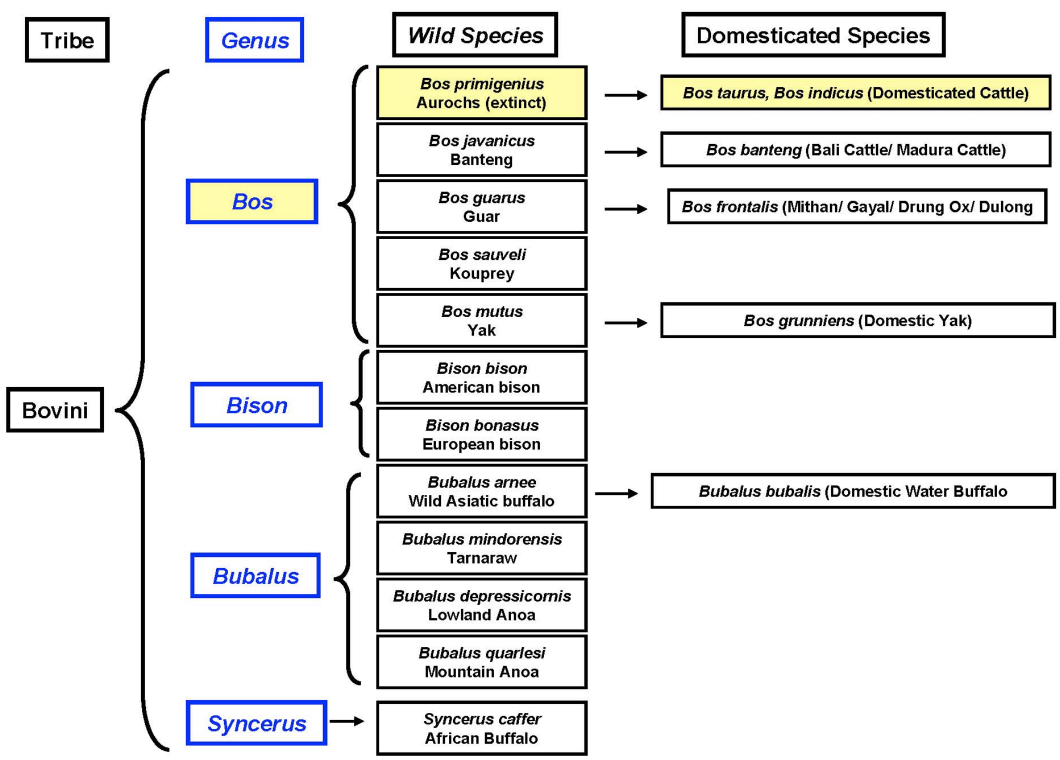
Generally, historical consideration of any topic primarily involves past written or pictorial accounts of the subject matter. In more recent times (~100 – 150 years ago), photographic images, moving pictures, tapes, sound recordings, computer archives and other electronic records have been employed to record and trace historical events. Although written language is the primary repository of historical events prior to the recent technological revolution , it bequeaths us a fragmentary and incomplete account, principally because most day to day, mundane events are never recorded, and secondarily because events that occurred prior to the invention of the written word (5,100 – 5,500 years ago) (1) must be reconstructed via other means. In this regard, the chronicle of grass fed beef in human diets predates by far human mastery of the written word. Consequently, most of the direct evidence concerning the account of grass fed beef in the human diet must be recreated from archaeological, evolutionary and genetic evidence.

The First Grass Fed Beef Cattle: Aurochs

Figure 1 depicts the wild and domesticated species of cattle, bison (Bos and Bison) and buffalo (Bubalus and Syncerus) within the Bovini tribe (2). Almost 800 breeds of cattle are recognized worldwide (3); however, far and away the most economically important cattle breeds are genetically derived from only two species/subspecies: Bos taurus and Bos indicus which were domesticated from Bos primigenius (common name: Aurochs) starting ~ 11,000 years ago (4, 5). The considerable genetic divergence between zebu (B. indicus) and taurine (B. taurus) cattle indicates that at least two distinct subspecies of aurochs were independently domesticated (5). It is likely that zebu cattle were domesticated in the Indus Valley in Pakistan (6) and introduced to Africa (7), whereas European cattle have been primarily traced to an original domestication event in the Near East (4). However, present day European cattle breeds maintain a lineage that reflects genetic admixture with local wild aurochs (8 - 10) and African cattle (9, 10).

Aurochs (Bos primigenius) and modern breeds of cattle are members of the Bovinae Subfamily which evolutionarily diverged from the larger Bovidae Family between 12.0 and 14.3 million years ago (MYA) (11). Within the Bovini Tribe (Figure 1), the Bubalus and Syncerus genuses diverged 6.9 to 7.7 MYA, whereas the Bos/Bison divergence occurred later – between 3.3 and 4.8 MYA (11). Fossil evidence suggests that Aurochs evolved 1.5 – 2.0 MYA from a precursor species (Bos acutifrons) which co-existed in India 2 MYA with an extinct bison, Bison sivalensis (12, 13).

Figure 1. Wild and domesticated species within the tribe Bovini (family Bovidae, subfamily Bovinae), adapted from (2).

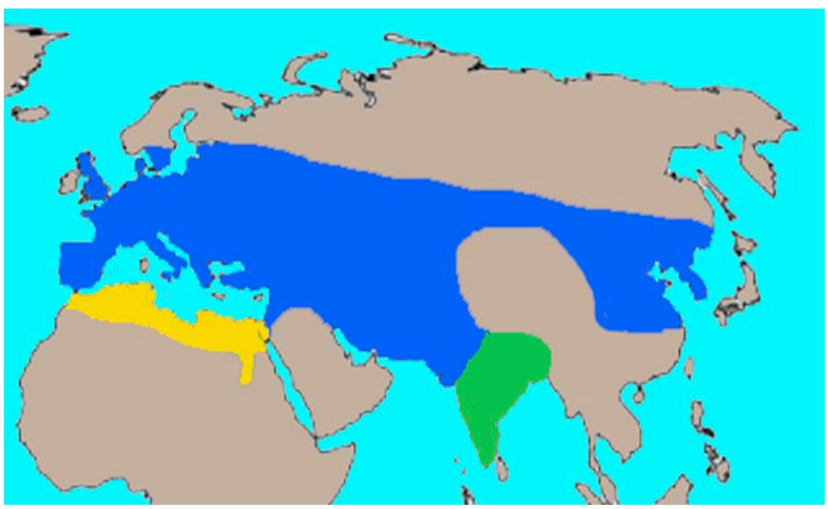


later

Figure 2 depicts the geographic range of the three subspecies of Aurochs which likely evolved from Bos acutifrons. It is thought that Bos primigenius namadicus represents the subspecies of Aurochs that was domesticated to become Bos indicus or Zebu cattle (6, 14), whereas Bos primigenius primigenius was the subspecies of Aurochs which later became the domesticated Bos taurus (4, 14). As was noted previously, current day breeds of European cattle likely maintain genetic admixture from backcrossing with local wild populations of aurochs and from zebu cattle from Africa (8-10).

Following their probable origin in India, the aurochs spread during the Pleistocene to other parts of Asia, Northern Africa, and Europe (14). It is likely that the aurochs first reached Europe through a southerly route, as the first European fossil remains date to 700,000 years ago in Spain (14). They later spread to central Europe and Russia, as evidenced from the earliest fossil finds dating to ~275,000 years ago in Germany (14). Aurochs withdrew during cold glacial periods to the Mediterranean and expanded

Figure 2. The geographic distribution of extinct aurochs (Bos primigenius) subspecies during the Pleistocene and Holocene. Blue: Bos primigenius, primigenius subspecies, Green: Bos primigenius namadicus, Yellow: Bos primigenius mauretanicus. Adapted from (14).



northward during warm interglacial eras, as they were not as well adapted to the cold such as other species including the Woolly Mammoths (Mammuthus primigenius) and Woolly Rhinoceros (Coelodonta antiquitatis) (14). In Europe, aurochs did not live in Ireland but did inhabit present day England by at least 170,000 years ago (15). The most northerly remains were found at 60° N near Saint Petersburg Russia (14).

Aurochs Extinction

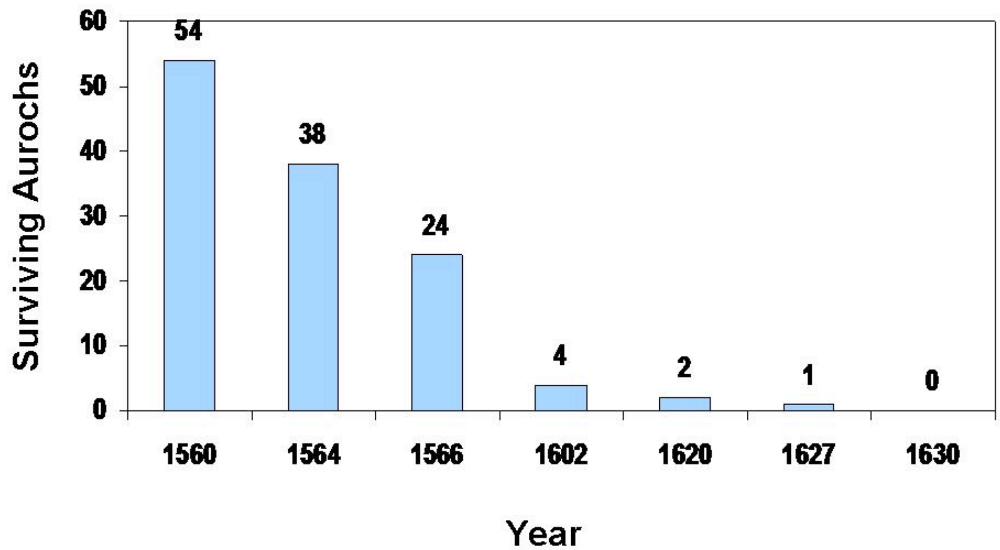
Over the course of their 1.5 – 2.0 million year presence in Europe, Asia and Africa, Aurochs survived numerous cyclical glacial and interglacial climatic changes. Although the fossil record is incomplete, the bulk of the evidence indicates the extinction of Aurochs began during the Holocene (the epoch following the end of the last glacial period ~11,000 years ago to the present) (14). In Europe the disappearance of the Aurochs started in the south and west and proceeded in a northeasterly fashion and finally ended in Poland in 1627 AD. Table 1 lists the last known occurrence of Aurochs in Europe, the Middle East and Africa.

Poland was the final known refuge of the Aurochs prior to their extinction in 1627. These animals numbered less than 100 individuals and lived in the primeval Jaktorow Forest, southwest of present day Warsaw where they were protected from hunting by dictate of the nobility (14, 17). Figure 3 shows the decline in numbers of this last remnant population in the twilight of their existence.

Table 1. Dates and locations for the last known occurrence of Aurochs in Europe, the Middle East and Africa. Adapted from (14, 16).

Date	Location
	Europe
7500 BP	Denmark islands
3300 BP	Great Britain
2400 BP	Netherlands
2000 BP	Denmark
2000 BP	Italy
802 AD	France
1000 AD	Switzerland
1100 AD	Sweden
1200 AD	Russia
1250 AD	Hungary
1408 AD	Germany
1627 AD	Poland
	Middle East and Africa
2600 BP	Iraq
2400 BP	Libya

Figure 3. Population decline in remnant Polish Aurochs from 1560 to 1630.



Aurochs Morphology, Behavior and Habitat

Aurochs were larger than contemporary cattle with bulls having a mean withers height of 170 cm and cows 150 cm compared to values of 140 cm (bulls) and 130 cm (cows) for domesticated cattle. From ice age cave drawings and 16th century pictures and descriptions, the fur colors of Aurochs are known (14). Both bulls and cows were born with a reddish-brown coat, but within 6 months the bull's coat changed into a deep blackish-brown with a narrow light colored stripe along the spine (Figure 4) whereas the cow's color remained unchanged throughout their lives (14). Both bulls and cows maintained a light colored area around their muzzles. Aurochs horns curved forward and inward (toward each other) and sometimes upward from the skull and were light colored with black tips. Male horn length (each horn) could reach more than 107 cm whereas cow horns were shorter (up to 70 cm) (14).

Figure 4. Morphology and fur color of male Aurochs.

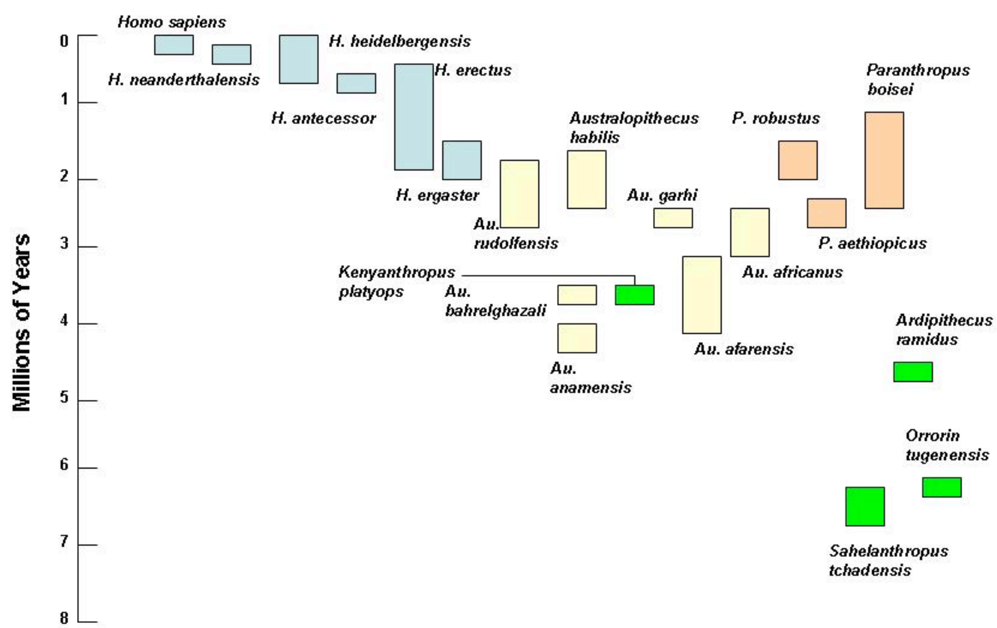
From historical descriptions aurochs were ill tempered and aggressive animals that would not flee when humans approached (14). Julius Caesar encountered these fierce beasts in the Black Forest of Germany in 53 BC and remarked, “They are a little below the elephant in size, and of the appearance, color, and shape of a bull. Their strength and speed are extraordinary; they spare neither man nor wild beast which they have espied. These the Germans take with much pains in pits and kill them. The young men harden themselves with this exercise, and practice themselves in this kind of hunting, and those who have slain the greatest number of them, having produced the horns in public, to serve as evidence, receive great praise.” (18).

By determining the natural landscape of geographic locales known to be inhabited by Aurochs during the Holocene as well as by establishing their preferred diet, it is possible to recreate their habitat. During the Holocene, both the Hercynian (Black) Forest of Germany and the Jaktorow Forest in Poland were dense heavily wooded areas interrupted by grassy marshes (14). Historical descriptions of aurochs suggest that they were grazers feeding primarily upon grasses and marsh plants as well as acorns, and bush and tree branches during winter. Hence, it is likely that Aurochs living in Europe during the Holocene favored open, grassy marsh areas found within heavily wooded forests (14).

Hunting of Aurochs by Hominins

In the 5-7 million-year period since the evolutionary emergence of hominins (bipedal primates within the taxonomic tribe, hominini; note that the newer term hominin supplants the previous term, “hominid”) 20 or more species may have existed (Figure 5) (19). In order for hominins to have hunted aurochs, both species would have had to

Figure 5. The hominin fossil record. Species are indicated with the dates of the earliest and latest fossil record. Adapted from Wood (19).



co-exist in the same temporal and spatial locations. Hominins evolved in Africa and subsequently spread to Europe and Asia, whereas Aurochs likely evolved in India and later spread to Europe and North Africa. The first fossil evidence of hominin presence outside of Africa appears at the Dmanisi site in present day Republic of Georgia by 1.75 MYA and consisted of Homo skeletal remains (perhaps Homo erectus) and primitive stone tools (20). Because the first Aurochs probably originated from the Indian subcontinent 1.5 – 2.0 million years ago (14), it is possible that the two species may have encountered one another in central Asia between 1.5 and 1.75 MYA, however there is no fossil evidence to either confirm or deny this potential encounter.

In Europe, the first Aurochs fossils appear 700,000 years ago in Spain (14), whereas early Homo remains have been uncovered in Northern Spain and dated to 780,000 years (20). Accordingly, it is likely that early members of our genus, Homo (perhaps Homo antecessor), inhabited the same geographic locales as Aurochs and that there would have been overlap in time. Early hominins living in Europe and Asia almost certainly consumed much of their daily energy as animal food because of the seasonal unavailability of plant foods (21); still the fossil record is incomplete and can neither corroborate nor refute the notion that Aurochs were hunted at this early juncture.

The earliest hominin existence in Northern Europe is dated to 700,000 years ago at 52 ° N in the UK (22); in contrast the first Aurochs fossils appear 170,000 years ago in the UK (15). As was the case with Aurochs, early humans in Europe were at the mercy of climate and were forced to retreat southward to warmer locales during glacial periods, but returned to more northerly latitudes during interglacials. Accordingly encounters between the two species at specific chronologies and latitudes likely were dependent upon long term climatic conditions.

In addition to climatic limitations to hunting Aurochs by hominins, a critical degree of behavioral and technological sophistication would have been necessary to successfully hunt and kill these large, dangerous beasts. The first hominins (perhaps H. antecessor) occupying Europe ~700,000 – 800,000 years ago (20, 22-23) utilized the more primitive Oldowan stone tool technology, whereas later hominin species (presumably Homo heidelbergensis) associated with fossil finds from Boxgrove in the UK (500,000 years ago) and Mauer (400,000 years ago) in Germany employed more sophisticated Acheulian tools (24, 25). In addition to the bifacial hand axes associated with Acheulian stone technology, these hominins crafted tapered wooden spears that appear in the fossil record in Germany by at least 400,000 years ago (26). A puncture wound in the scapula of a deer found at Boxgrove in the UK and dated to ~500,000 years ago is indicative that sharpened wooden spears would have been used as a primary weapon to kill large mammals (27). In support of this concept is the spectacular find near Hannover, Germany of a 2.4 meter yew spear found thrust between the ribs of the extinct straight tusked elephant (Palaeoloxodon antiquus) and dated to 125,000 years ago (28). The hominin species which would have hunted and killed this beast was almost certainly Homo neanderthalensis, as no other hominins are known from the fossil record in Europe at the time (29). In summary, by at least 500,000 years ago, and possibly as early as 700,000 years ago, hominins inhabiting Europe maintained an arsenal of weapons and tools as well as the behavioral sophistication necessary to bring down and butcher large mammals, including Aurochs, that may have inhabited this region.

Definitive Hominin and Aurochs Interaction

Although circumstantial evidence demonstrates that the very earliest hominins living in central Asia (1.75 MYA) and in Europe (700,000 years ago and 500,000 years ago) may have encountered and hunted Aurochs, direct fossil evidence for these actions come later and are attributed to Neanderthals (Homo neanderthalensis) and modern humans (Homo sapiens).

Recent excavations in France near the mouth of the river Somme have uncovered Aurochs and other large fossilized animal (elephant and rhinoceros) bones with flint cut marks made during butchery and dated to a period (125,000 years ago) in which Neanderthals exclusively inhabited this part of France. Although these fossils represent definitive evidence for the consumption of Aurochs flesh by hominins, it is unclear whether Aurochs were hunted, scavenged or both. Given that Neanderthals were known to hunt megafauna such as elephants by plunging wooden spears into the chest cavity (28), it is reasonable to believe that similar acts were carried out upon smaller mammals such as Aurochs.

By analyzing staple isotopes of various elements in fossilized hominin bones and contrasting these signatures to isotopes in known prey animals, it is possible to determine the relative proportion of prey animals in the diet of the predator (31, 32). A recent study of a 35,000 year old Neanderthal specimen from France has shown that the flesh of Bovinae (except reindeer, but including Aurochs) comprised 58 % of the meat consumed by this particular individual (32). Consequently, direct chemical evidence supports the fossil data that Aurochs flesh would have been a component of Neanderthal diet.

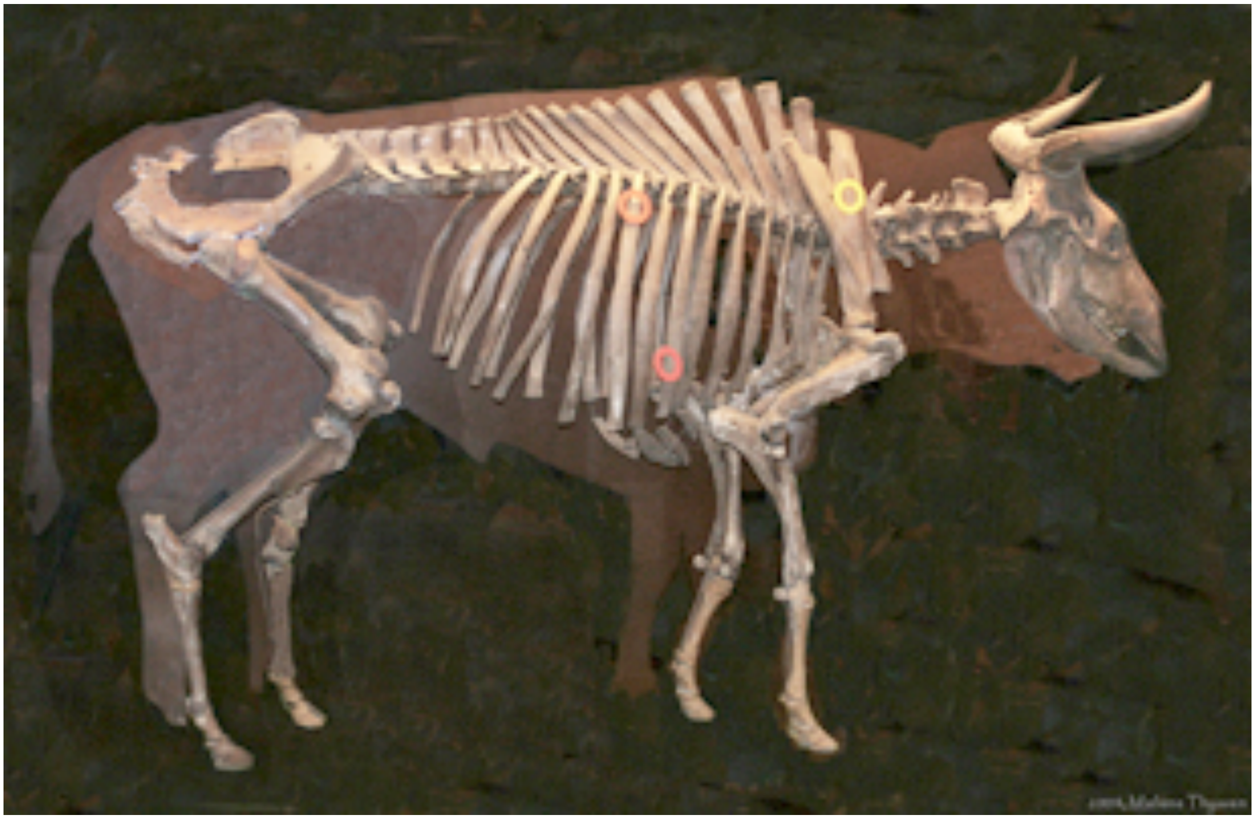
Modern humans (Homo sapiens) evolved in Africa approximately 200,000 years ago, and first left Africa about 100,000 years ago to briefly colonize the Levant (33). However, it was not until ~ (60,000 – 70,000 years ago) that our species began begin to permanently leave Africa and inhabit the entire planet (33). In their migration out of Africa, modern humans are thought to have first headed eastward and likely arrived in Australia by about 56,000 years ago (34). They then headed west into Asia and appeared in Europe by ~ 40,000 years ago (33). Accordingly, as modern humans dispersed from Africa, it is almost certain that whenever and wherever Aurochs were encountered, they were likely hunted.

In support of this notion are the magnificent European cave drawings of Aurochs from Chauvet Cave (~30,000 years ago), Pechmerle Cave (~25,000 years ago), Lascaux Cave (~15,000 years ago), Altamira Cave (~12,000 years ago) and others. Stone pictographs of Aurochs also appear in Libya including the hunting scene shown in Figure 6 (35). Fossilized remains of Aurochs bones with cut marks and with flint arrowheads in their fossilized remains indicate these animals were regularly hunted (36-39). Figure 7 depicts the well-known Vig Aurochs whose fossilized bones are preserved in the National Museum of Denmark. This specimen dates to 10,600 years BP and was wounded on two separate occasions by modern human hunters living in Denmark at the time. The first wound (circled in yellow) to the right scapula was caused by a flint arrowhead that lodged in the bone and healed over. The two abdominal wounds (circled in red) proved fatal and were also the result of flint arrowheads which remained lodged between the ribs. Apparently, the animal escaped from the hunters and fled to a small lake in present day Odsherred, Denmark where it sank to the bottom and died, denying the hunters their kill. The fossilized remains were discovered in 1905 (39).

In addition to the archeological evidence, there are numerous historical accounts (both pictorial and written), illustrating and describing the hunting of Aurochs. King Ramses II (1197 – 1165 BC) of Egypt is said to have hunted Aurochs in Northern Mesopotamia (presently Iraq), as did the Assyrian king Senacherib (704-681 BC) (16). Julius Caesar describes Aurochs hunting in 53 BC by tribes people in the present day Black Forest (18), and in France, Charlemagne is known to have hunted these magnificent animals in 802 AD (16). In Poland during the 13th, 14th and 15th centuries AD extensive descriptions exist of kings and nobility hunting Aurochs (17). Figure 3 suggests that the last Aurochs hunt occurred in the mid 15th century just prior to their extinction in 1627.

Figure 6. Undated cave drawing from Libya depicting an Aurochs hunt (35).

Figure 7. The Vig Auroch from Denmark. The Circles represent flint arrowhead wounds (39).



How the killing was done

There certainly would have been no single procedure for hunting and killing animals by Stone Age hominins. Killing procedures would have varied by prey size, intelligence, ferocity and other physical attributes in conjunction with available weapon technology. Table 2 lists the advent of the most common weapons used by Stone Age hominins. Until ~ 60,000 years ago, the most effective weapon for killing large animals would have been the sharpened wooden spear, whereas smaller animals could have been clubbed, stoned, speared, strangled or violently thrust upon the ground or hard objects.

Table 2. Time line of various weapon/killing technology by Stone Age Hominins.

Weapon	Probable Advent	Direct evidence
Physical assault (strangulation, hand/foot blows, body slams)	2.6 MYA or earlier	
Stone, boulder and stick throwing	2.6 MYA or earlier	
Wooden or bone clubs	2.6 MYA or earlier	
Unsharpened wooden spears	2.6 MYA or earlier	
Sharpened wooden spears	2.0 – 2.6 MYA	500,000 YA
Fire hardened wooden spears	300,000 YA	125,000 YA
Stone or bone arrowheads hafted to wooden spears		60,000 YA
Sling	~ 20,000 YA	
Atlatl (spear thrower)		18,000 YA
Bow and arrow		11,000 – 12 ,000 YA

The fossil record indicates that sharpened wooden spears were used by hominins to kill large mammals by at least 500,000 years BP (24, 26, 27). It is quite likely that hominins used these weapons to kill animals much earlier, as the stone technology (Oldowan) required to manufacture sharpened wooden spears was available by 2.6 MYA (40). A wooden spear thrust into the body cavity of any animal regardless of its size would likely have proved to be eventually fatal in most instances. The most deadly spearing occur if the heart or any of its major arteries are pierced. Death ensues within minutes from severe hemorrhaging. Similarly, if both lungs are penetrated by either a single spear transversing the thorax or from multiple spearings on both sides of the thorax, death occurs rapidly (within minutes) because of the ensuing bilateral tension pneumothorax causing lung collapse which in turn triggers ventricular fibrillation and death (41). A spear entering a single lung and not severing any major arteries would not necessarily be immediately fatal; however it would weaken the animal cause blood loss and make it vulnerable to continued attacks. Spears entering the abdominal cavity would be lethal if they pierced the liver, however wounds to the gut would not cause death immediately (41).

It is not entirely clear if sharpened wooden spears were thrown or primarily used as thrusting weapons. Modern day experiments with thrown wooden spears indicate that they are largely ineffective at penetrating the hides of large mammals except at close ranges (< 10 – 15 meters); hence their primary use may have been as thrusting weapons (42, 43). In this regard, early hominins would have had to approach Aurochs at near point blank range to kill them with sharpened wooden spears. Only during the end of the upper Paleolithic period with the advent of the atlatl and bow and arrow could killing have been accomplished at safer long distances. Indeed, these technological advances may have hastened the extinction of the Aurochs.

Grass Fed Beef: 11,000 Years Ago to the Present

The archaeological, fossil and genetic evidence demonstrates that hominins have consumed the flesh and organs of Aurochs for more than a half million years. During the early domestication process beginning 11,000 years ago and beyond it is unlikely that the diets of these animals changed significantly from their wild ancestors. Compared to contemporary practices, early domestic cattle were probably kept with a bare minimum of control. There is little or no evidence of extended fencing or large barns, as cattle

were likely kept as free roaming herds without confined enclosures. To maintain control, the herds were provided access to adequate fodder by being driven between pastures that had been created by clearing and burning woodland and forest (44). Hence, their former principal indigenous food source (grass and forbs) would have been largely preserved.

Since their initial domestication, almost 800 breeds of cattle have been developed (3) as specific traits (milk production, meat, heat tolerance, behavior etc.) were selected by humans overseeing breeding and reproduction. Throughout most of recorded history, cattle were typically fed by providing them free access to pastures, grasslands and range land (44). Only in the past 150-200 years have these animal husbandry practices substantially changed.

Technological developments of the early and mid 19th century such as the steam engine, mechanical reaper, and railroads allowed for increased grain harvests and efficient transport of both grain and cattle, which in turn spawned the practice of feeding grain (corn primarily) to cattle sequestered in feedlots (45). In the U.S., prior to 1850 virtually all cattle were free range or pasture fed and typically slaughtered at 4-5 years of age (45). By about 1885, the science of rapidly fattening cattle in feedlots had advanced to the point where it was possible to produce a 545 kg steer ready for slaughter in 24 months and which exhibited “marbled meat” (45). Wild animals and free ranging or pasture fed cattle rarely display this trait (46). Marbled meat results from excessive triacylglycerol accumulation in muscle interfascicular adipocytes. Such meat has greatly increased saturated fatty acid content, a lower proportion of ω-3 fatty acids and more ω-6 fatty acids (46, 47).

Modern feedlot operations involving as many as 100,000 cattle emerged in the 1950s and have developed to the point where a characteristically obese (30 % body fat) (48) 545 kg pound steer can be brought to slaughter in 14 months (49). Although 99% of all the beef consumed in the U.S. is now produced from grain-fed, feedlot cattle (50), virtually no beef was produced in this manner as recently as 200 years ago (45). Accordingly, cattle meat (muscle tissue) with a high absolute saturated fatty acid content, low ω-3 fatty acid content and high ω-6 fatty acid content represents a recent component of human diets (46).

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Grass-Fed Beef in the Human Diet:
II. Applications to Clinical Disease

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Introduction

Beginning in the mid 1980's a series of key publications in mainstream medical and nutrition journals (1-4) triggered an increased awareness of the relevance of ancestral human diets to the health and well being of contemporary people. Because of these insights as well as others gleaned from a variety of medical branches of learning, an entirely new academic discipline dubbed "evolutionary medicine" was born (5). The primary tenet of evolutionary medicine is that the profound changes in the environment (e.g. in diet and other lifestyle conditions) that began with the introduction of agriculture and animal husbandry approximately 10,000 years ago occurred too recently on an evolutionary timescale for the human genome to adjust (1-5). In conjunction with this discordance between our ancient, genetically-determined biology and the nutritional, cultural and activity patterns of contemporary western populations, many of the so-called diseases of civilization have emerged (1-5).

With regard to diet and health, food staples and food processing procedures introduced during the Neolithic and Industrial era have fundamentally altered seven crucial nutritional characteristics of ancestral hominin diets: 1) glycemic load, 2), fatty acid composition, 3) macronutrient composition, 4) micronutrient density, 5) acid/base balance, 6) sodium/potassium ratio, and 7) fiber content. Each of these nutritional factors either alone or combined with some, or all, of the remaining factors underlie the pathogenesis of a wide variety of chronic diseases and maladies which almost universally afflict people living in western, industrialized societies (6). In this regard, dramatic changes in cattle husbandry practices in the past 200 years have caused fundamental changes in the nutritional characteristics of domesticated beef that may adversely impact human health by altering the fatty acid composition, the macronutrient composition, and the micronutrient composition (6).

Changes in Cattle Husbandry and Feeding Practices since the Industrial Revolution

Since their initial domestication, almost 800 breeds of cattle have been developed (7) as specific traits (milk production, meat, heat tolerance, behavior etc.) were selected by humans overseeing breeding and reproduction. Throughout most of recorded history, cattle were typically fed by providing them free access to pastures, grasslands and range land (8). Only in the past 150-200 years have these animal husbandry practices substantially changed.

Technological developments of the early and mid 19th century such as the steam engine, mechanical reaper, and railroads allowed for increased grain harvests and efficient transport of both grain and cattle, which in turn spawned the practice of feeding grain (corn primarily) to cattle sequestered in feedlots (9). In the U.S., prior to 1850 virtually all cattle were free range or pasture fed and typically slaughtered at 4-5 years of age (9). By about 1885, the science of rapidly fattening cattle in feedlots had advanced to the point where it was possible to produce a 545 kg steer ready for slaughter in 24 months and which exhibited "marbled meat" (9). Wild animals and free ranging or pasture fed cattle rarely display this trait (10). Marbled meat results from excessive triacylglycerol accumulation in muscle interfascicular adipocytes. Such meat typically has greatly increased total and saturated fatty acid contents, reduced protein (by energy), a lower proportion of ω-3 fatty acids, higher ω-6 fatty acids and a higher ω-6/ω-63 fatty acid ratio (10, 11).

Modern feedlot operations involving as many as 100,000 cattle emerged in the 1950s and have developed to the point where a characteristically obese (30 % body fat) (12) 545 kg pound steer can be brought to slaughter in 14 months (13). Although 99% of all the beef consumed in the U.S. is now produced from grain-fed, feedlot cattle (14), virtually no beef was produced in this manner as recently as 200 years ago (9). Accordingly, cattle meat (muscle tissue) with high total fat, low protein (by energy), high absolute saturated fatty acid content, low ω-3 fatty acid content, high ω-6 fatty acid content and an elevated ω-6/ω-3 fatty acid ratio represents a recent component of human diets that may adversely influence health and well being (4, 10, 11).

Grain Fed, Feed Lot Cattle: Nutritional Consequences for Humans

The practice of feeding grain and concentrated feed to cattle sequestered for long periods in feedlots is not necessarily benign, but rather yields meat with a number of potentially deleterious nutritional characteristics, particularly when compared to either wild animals or grass fed cattle (10, 11). Table 1 summarizes a number of potential nutritional differences that have been identified between the meat of feed lot and grass fed beef cattle.

Before each of these nutritional qualities is examined in more detail a few important points need to be brought up in. First, the fatty acid concentrations in grass and feed lot produced meat typically are reported in the literature in two ways: 1) as a percentage of total fatty acids, or 2) gravimetrically as (mg fatty acid/100 g muscle tissue). The former procedure may be misleading because the relative percentage of any fatty acid does not reveal the absolute amount of the fatty acid in the sample (18). Hence,

Table 1. Potential nutritional differences between feed lot and grass fed beef.

Nutrient	Grass	Feed Lot	References
ω-3 fatty acids	Higher	Lower	(11, 15-30, 40, 47, 48)
ω-6 fatty acids	Lower	Higher	(15, 16, 18, 21, 27, 48)
ω-6/ ω-3 ratio	Lower	Higher	(11,15-21,27-30, 40, 47, 48)
Long chain fatty acids (both ω-3 and ω-6)	Higher	Lower	(11,15, 16, 17, 21, 28, 29, 47)
Fat content	Lower	Higher	(11, 15, 16, 18-21, 27, 40)
Saturated fatty acids	Lower	Higher	(11, 15-18, 27)
P/S Ratio	Higher	Lower	(11,15-18, 21, 27)
Conjugated linoleic acid	Higher	Lower	(11,15,17, 30-36)
Vitamin E	Higher	Lower	(25, 37-40)
Vitamin C	Higher	Lower	(40)
Beta carotene	Higher	Lower	(37, 40-42)
Protein content	Higher	Lower	(43)

the latter method of reporting fatty acid concentrations is more useful from a human nutritional perspective (21).

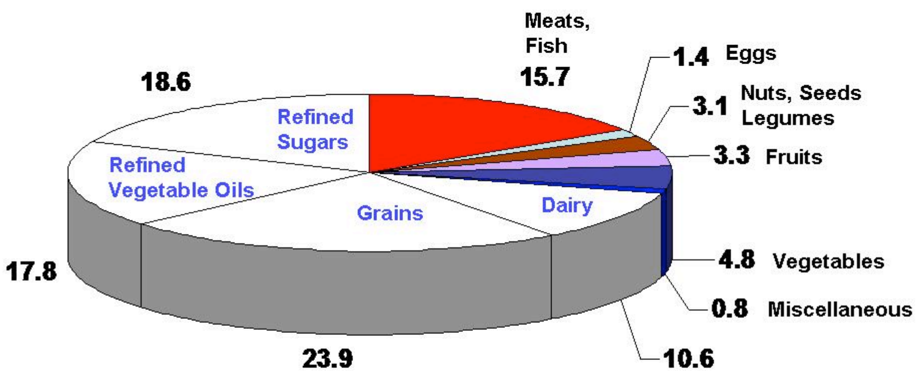
Secondly, fatty acid comparisons between grass and grain produced beef are not only dependent upon the type of feed, but also upon the total amount of feed used in finishing, which in turn influences the total fat and fatty acid content of the beef. For instance, in U.S. feedlot produced beef, there is a progressive increase in total fat with time on feed (16, 49). Concurrent with this increase in fatness are increases in total saturated fatty acids, ω-6 fatty acids, the ω-6/ ω-6 fatty acid ratio, along with declines in total ω-3 fatty acids and the polyunsaturated/saturated (P/S) ratio (16). Additionally, because of differing feeding practices as well as differing genetics, European grain produced cattle are frequently leaner than their grass fed counterparts (21, 29, 47) and much leaner than U.S. grain fed cattle (21, 29, 47, 48). Consequently, comparisons of certain fatty acids between grass and grain produced beef in Europe and the U.S. may be confounded by total fat contents that are greatly dissimilar.

The total fat (triglyceride) content of a beef cut is typically measured by trimming the meat's surface of visible fat and epimysial connective tissue and then measuring the remaining fat by weight. This fat is frequently referred to as "intramuscular fat" (16, 51) which sometimes is used synonymously with the term "marbling fat". In fact, the majority of total triglycerides in a cut of beef occurs not within muscle cells themselves (e.g. intramuscular fat), but rather within adipocytes located between the muscle bundles (fasiculi) of a muscle. Accordingly, intramuscular storage of triglyceride is small compared to that in interfascicular adipocytes (52).

Finally, certain statistically significant nutritional differences between grass and grain produced beef, may have little or no physiological relevance because: 1) the relative difference is small compared to the daily recommended intakes (DRI), or 2) the nutrient difference pales in comparison to contributions of the same nutrient by another food group. For instance, pasture raised beef contains 58.9 % more vitamin C than grain produced beef (40). However the absolute difference in vitamin C concentration between pasture produced beef (25.3 µg/g beef) and grain produced beef (15.92 µ/g beef) amounts to 5.38 µg. Relative to the DRI for vitamin C for adult males (90 mg), the vitamin C contribution by either pasture or grain produced beef is so small that it has no nutritional relevance. Similar arguments could be made for beta carotene and vitamin E as both grass and grain produced beef represent negligible human dietary sources of either nutrient (40). The central human nutritional issue here is not vitamin C, E or beta carotene concentrations in either grass or grain produced beef, but rather the contribution of these nutrients by other food groups which are rich sources of these dietary elements. U.S. diet, and within this food group, the daily per capita beef consumption amounts to 82 grams (44). Many of the current health problems and chronic diseases which afflict the American public result from excessive consumption of refined sugars, grains, vegetable oils, fatty meats and dairy products (2, 4, 6). Human health and well being could potentially be improved by including more lean grass fed beef into the U.S. diet at the expense of fatty, feedlot-produced meats, refined sugars, grains, vegetable oils and high fat dairy products.

Figure 1. Relative contribution of energy by various food groups in the U.S. diet.

Adapted from (43).



Grass vs. Grain Fed Beef: Omega 3 and Omega 6 Fatty Acids

There is little argument that grass fed cattle accumulates more ω-3 fatty acids in their tissues than grain fed cattle (11, 15-30, 40, 47, 48). This nutrient amplification in tissues occurs because the concentration of 18:3n3 (alpha linolenic acid [ALA]) in pasture grass is 10 to 15 times higher than in grain or typical feedlot concentrates (30). Despite the biohydrogenation of dietary polyunsaturated fatty acids (PUFA) that occurs in the rumen, sufficient 18:3n3 escape the rumen intact and available for absorption in a variety of tissues, including muscle and liver (45). In mammals the liver represents the primary tissue which chain elongates and desaturates 18:3n3 into long chain ω-3 fatty acids (20:5n3, 22:5n3 and 22:6n3) which then can be deposited in muscles and other tissues (46).

Not only do feed lot cattle maintain lower ω-3 fatty acids in their tissues than grass fed cattle, but a characteristic increase in the total ω-6 fatty acids occurs (15, 16, 18, 21, 27, 48) as a result of grain feeding (16). Because typical cereals fed to cattle such as maize (ω-3/ ω-6 = 70.7) and sorghum (ω-6/ ω-3 = 16.2) contain very little 18:3n3 and much higher 18:2n6 (50), the cattle's tissues reflect the fatty acid balance of the grains they consume. Table 2 displays concentrations of ω-3 and ω-6 fatty acids in grass produced beef reported in the literature, and Table 3 reports the counterpart for grain produced beef.

Table 2. Concentrations of ω-3 and ω-6 fatty acids in grass fed beef (mg fatty acid/100 g muscle tissue). LC ω-3 (20:5n3, 22:5n3, 22:6n3).

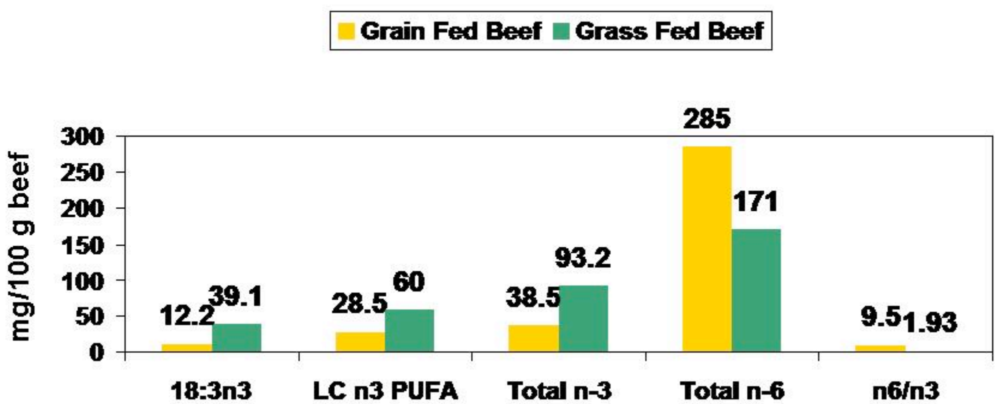
18:3n3	LC ω-3	total ω-3	total ω-6	ω-6/ ω-3	tissue	Reference
na	na	52	139	2.67	muscle	(27)
68	na	na	na	na	biceps	(19)
35	na	na	na	na	longissimus	(19)
24	37	61	138	2.26	semitendinosus	(18)
36.3	52.8	89.1	115	1.29	triceps	(21)
32.7	39.4	72.1	95	1.32	longissimus	(21)
48.5	69.5	118	160	1.36	gluteobiceps	(21)
34.5	49.5	84	120	1.43	gluteus	(21)
23.4	36.6	60	250	4.17	longissimus	(16)
35.3	51	86.3	98	1.2	longissimus	(29)
47.4	61.2	108.6	148	1.4	longissimus	(29)
48.9	104.9	154.7	334	2.16	rump cut	(15)
32.4	65.2	97.6	192	1.96	strip loin cut	(15)
42.1	93.0	135.1	258	1.91	blade cut	(15)
(Mean ± SD)						
(39.1+ 2.0)	**(60.0+22.3)**	**(93.2+31.4)**	**(171 + 74)**	**(1.93 + 0.85)**		

Figure 2 shows that an average 100 g sample of grass fed beef contains 3.2 times more 18:3n3, 2.1 times more long chain ω-3 fatty acids and 2.4 times more total ω-3 fatty acids than an average sample of grain produced beef, whereas the total ω-6 content of grain fed beef is 1.7 times greater than grass fed beef.

Table 3. Concentrations of ω-3 and ω-6 fatty acids in grain fed beef (mg fatty acid/100 g muscle tissue). LC ω-3 (20:5n3, 22:5n3, 22:6n3).

18:3n3	LC ω-3	total ω-3	total ω-6	ω-6/ ω-3	tissue	Reference
na	na	16	275	17.2	muscle	(27)
18	na	na	na	na	biceps	(19)
14	na	na	na	na	longissimus	(19)
11	35	46	183	5.28	semitendinosus	(18)
16	29	45	325	7.22	psoas	(18)
9	18	27	240	8.89	longissimus	(18)
9	16.7	25.7	251	9.76	triceps	(21)
10.4	13.9	24.3	224	9.20	longissimus	(21)
10.9	19.5	30.4	315	10.35	gluteobiceps	(21)
9.4	6.8	16.2	245	15.2	gluteus	(21)
9.5	18	27.5	397	14.45	longissimus	(16)
9.6	17.8	28.8	283	9.28	longissimus	(29)
5.3	19.3	24.6	332	13.7	longissimus	(29)
21.4	75.3	96.6	399	4.13	rump cut	(15)
14.9	48.4	63.3	254	4.01	strip loin cut	(15)
15.1	52.8	67.8	272	4.01	blade cut	(15)
(Mean $\pm$ SD)						
(12.2+4.2)	**(28.5+19.5)**	**(38.5 + 23.1)**	**(285 + 62)**	**(9.5 + 4.4)**		

Figure 2. Literature summary (n=7 studies) of ω-3 and ω-6 fatty acid differences between grass and grain produced beef. LC ω-3 (20:5n3, 22:5n3, 22:6n3).



Grass vs. Grain Fed Beef: Total Fat, Saturated Fatty Acids, Monounsaturated Fatty acids and Polyunsaturated Fatty Acids

Tables 4 and 5 list total fat, saturated, polyunsaturated and monounsaturated fatty acids differences between grain and grass fed beef that have been reported in the literature. As was previously mentioned, the total fat content of feedlot produced beef is highly dependent upon the time on feed (TOF). Because this variable was not reported in all studies in Tables 4 and 5, it is more useful to evaluate how TOF influences total fat and saturated fatty acid content. Figure 3 demonstrates how fat content increases by both weight and energy with increasing TOF in feedlot produced beef. Figure 4 depicts increases in saturated fat with TOF in feedlot produced beef. Table 6 lists seven common USDA beef quality grades and the associated amount of marbling and fat percentage by weight with these cuts of meat. Figure 5 illustrates how these quality grades translate into total fat percentages by energy.

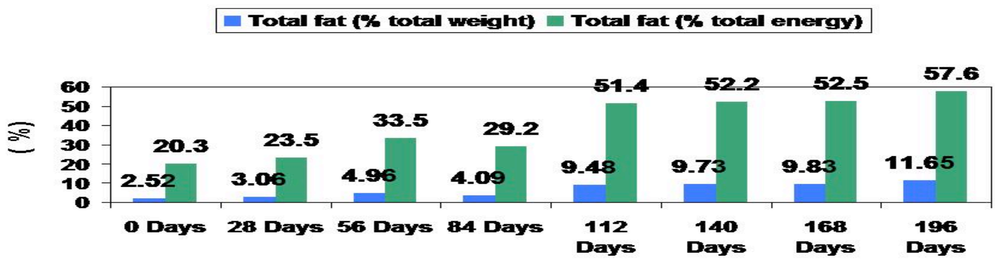
Table 4. Concentrations of various fatty acids in grass fed beef (mg fatty acid/100 g muscle tissue). SAT: saturated fatty acids, PUFA: polyunsaturated fatty acids, MUFA: monounsaturated fatty acids.

Total fat	SAT (mg)	PUFA (mg)	PUFA/SAT	MUFA	tissue	Reference
2400	933	191	0.20	1276	muscle	(27)
2040	na	na	na	na	biceps	(19)
2650	na	na	na	na	longissimus	(19)
3080	910	1055	1.16	1115	semitendinosus	(18)
2650	1022	204	0.20	1424	triceps	(21)
2860	1220	167	0.14	1473	longissimus	(21)
3390	1231	278	0.23	1881	gluteobiceps	(21)
2240	856	205	0.24	821	gluteus	(21)
2520	1192	310	0.26	1018	longissimus	(16)
3940	1773	224	0.13	1943	longissimus	(29)
1980	892	280	0.31	808	longissimus	(29)
2792	1118	489	0.43	1185	rump cut	(15)
2120	900	289	0.32	931	strip loin cut	(15)
2138	801	393	0.49	944	blade cut	(15)
(Mean ± SD)						
(2629 ± 559)	**(1071 ± 267)**	**(340 ± 243)**	**(0.34 ± 0.28)**	**(1235 ± 382)**		

Table 5. Concentrations of various fatty acids in grain fed beef (mg fatty acid/100 g muscle tissue). SAT: saturated fatty acids, PUFA: polyunsaturated fatty acids MUFA: monounsaturated fatty acids.

Total fat	SAT (mg)	PUFA (mg)	PUFA/SAT	MUFA	tissue	Reference
5000	2028	291	0.14	2681	muscle	(27)
4330	na	na	na	na	biceps	(19)
5630	na	na	na	na	longissimus	(19)
4760	1909	2196	1.15	1525	semitendinosus	(18)
1570	540	277	0.51	753	triceps	(21)
2100	821	248	0.30	1031	longissimus	(21)
2010	692	345	0.50	973	gluteobiceps	(21)
1780	633	262	0.41	885	gluteus	(21)
9480	4798	424	0.09	4258	longissimus	(16)
4540	2083	346	0.17	2111	longissimus	(29)
1700	707	370	0.52	623	longissimus	(29)
4824	1865	496	0.27	2463	rump cut	(15)
3614	1568	317	0.20	1729	strip loin cut	(15)
3175	1172	340	0.29	1663	blade cut	(15)
(Mean ± SD)						
(3894 ± 2140)	**(1568 ± 1178)**	**(493 ± 541)**	**(0.38 ± 0.28)**	**(1725 ± 1044)**		

Figure 4. Changes in saturated fat content of feedlot produced beef with time on feed. Adapted from (16).



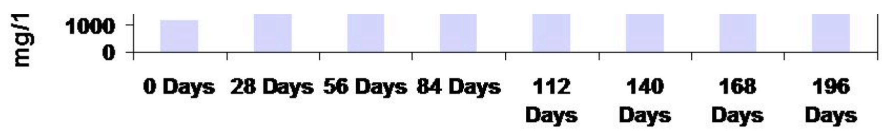
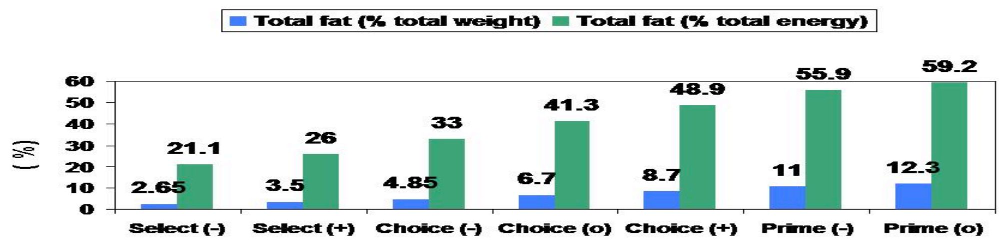


Table 6. Seven USDA beef quality grades and conversion to marbling scores and total fat percentage by weight. Adapted from (51).

Quality Grade	Marbling Degree	Marbling Score	Total fat % (by weight)
Select (-)	Slight (0 -- 40)	4.0 – 4.4	2.3 – 3.0
Select (+)	Slight (50 – 90)	4.5 – 4.9	3.1 – 3.9
Choice (-)	Small (0 – 90)	5.0 – 5.9	4.0 – 5.7
Choice (o)	Modest (0 – 90)	6.0 – 6.9	5.8 – 7.6
Choice (+)	Moderate (0 – 90)	7.0 – 7.9	7.7 – 9.7
Prime (-)	Slightly Ab (0 – 90)	8.0 – 8.9	9.9 – 12.1
Prime (o)	Moderately Ab (0 –)	9.0 –	12.3 –

Figure 5. Seven USDA beef quality grades and total fat percentage by % weight and by % total energy. Adapted from (51).



Tables 4 and 5 and Figures 3 to 6 demonstrate that typical feedlot produced beef contains 2- 4 times more total and saturated fat than grass fed beef. Additionally, with increasing TOF, there is a proportional increase in both total and saturated fat which is positively correlated with the marbling score.

Grass vs. Grain Fed Beef: Conjugated Linoleic Acid

Table 7 lists a number of studies evaluating differences in CLA concentrations between grass and grain produced beef. On average the concentration of CLA is between 2 to 3 times higher in grass fed beef on a per fat weight basis. Because the fat content of grass fed beef is approximately 2 to 3 times lower (Tables 4, 5; Figures 3-5) than grain produced beef, the concentration of CLA between two 100 g samples of grass and grain produced would be approximately equal. However, the nutritional advantage of grass fed beef would be that less total fat and saturated fat would be consumed to achieve an approximately equal CLA intake.

Grass vs. Grain Fed Beef: Protein

On a per weight basis, the average 100 gram sample of grass fed beef contains 2.6 g of total fat (Table 4), whereas a comparable sample of grain fed beef contains 3.9 g fat (Table 5). However, this value for grain fed beef may be low, as demonstrated by Table 6 which lists the average fat contents of USDA quality beef grades. In the U.S., Choice Beef [either Choice (o) or Choice (+)] averaging between 5.8 and 9.7 % fat by weight are more representative of the average cut preferred by consumers (53).

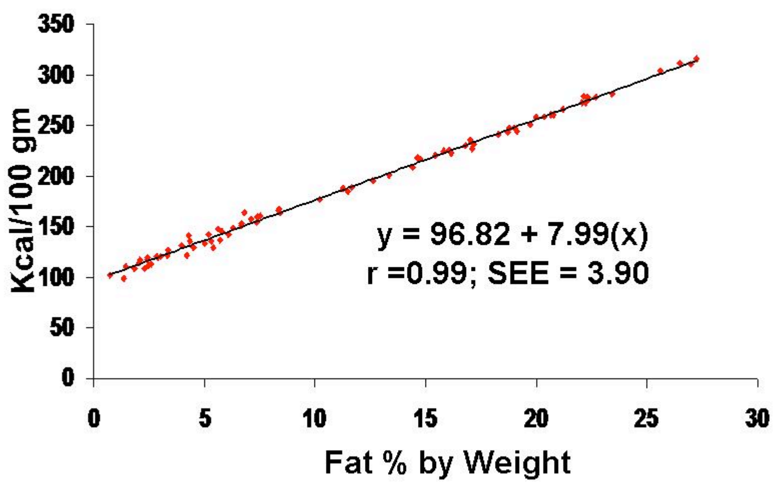
Table 7. Literature summary (n= 5 studies) of CLA (cis-9, trans-11 18:2) differences between grass and grain produced beef (mg CLA/g fat).

Grass Fed	Grain Fed	Tissue	Reference
4.1	2.6	longissimus	(11)
3.2	2.8	semitendinosus	(11)
5.2	3.1	supraspinatus	(11)
11.3	5.2	rump cut	(15)
6.7	4.5	strip loin	(15)
8.0	4.9	blade cut	(15)
10.8	3.7	longissimus	(17)
8.4	7.5	longissimus (a)	(30)
8.7	7.2	longissimus (b)	(30)
8.0	3.2	longissimus	(33)
(Mean + SD)			
(7.4 + 2.7)	**(4.5 + 1.8)**		

Because of the relative constancy of the protein content of the fat free mass (FFM), the energy density of edible cuts of beef is almost entirely dependent upon the percentage of fat in the sample (42). As the fat content (by weight) of beef samples increase, there is a linear increase in the energy density of the sample (Figure 6) (42).

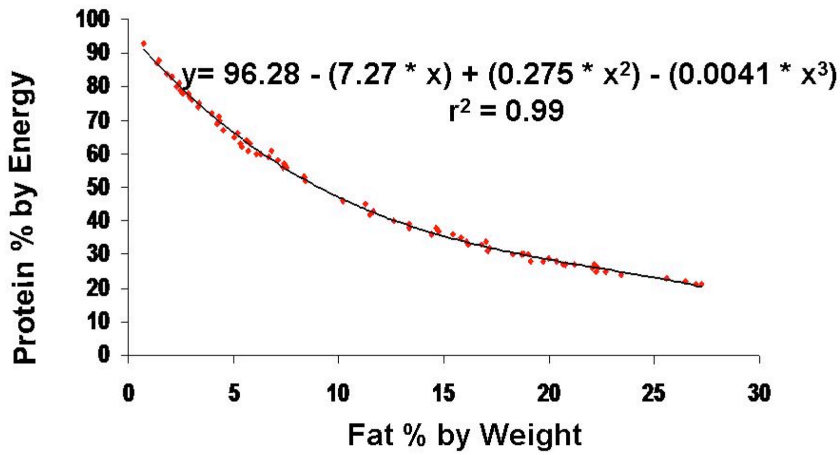
Figure 9 shows the cubic decline in the protein content of a beef sample as fat increases. Note that grass fed beef contains 76.5 % of its total energy as protein, whereas the preferred USDA Choice (+) only contains 48. 9 % of its total energy as protein. These data indicate that increased consumption of fattier cuts of meat have the capacity to reduce the dietary protein intake as well as the important trace nutrients (Fe, Zn, vitamins B12, B6 and niacin) concentrated in the lean muscle component of beef.

Figure 6. Regression of percentage fat weight to energy (kcal/100 g) in raw cuts of beef (n = 86).



Associated with the increase in fat content (by weight) is a characteristic decline in the protein content by energy that can be described by the cubic relationship depicted in Figure 7 (42).

Figure 7. Regression of percentage fat weight to percentage protein energy (kcal/100 g) in raw cuts of beef (n = 86).

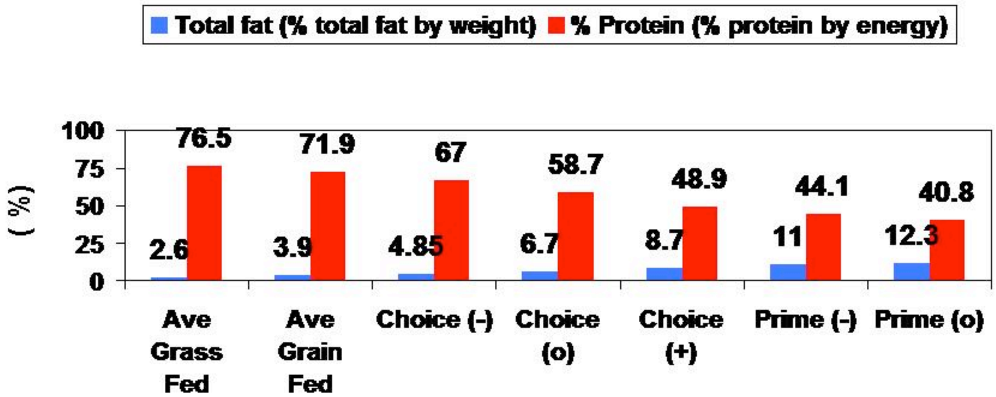


Potential Health Improvements by Increasing Grass Fed Beef Consumption

A number of scenarios involving improvements in human health can be envisioned by including more and more lean grass fed beef into the diets of U.S. citizens. These scenarios are dependent upon the specific foods and food groups that would be potentially displaced by grass fed beef and by the amount of grass fed beef that would included in the diet. The health impact of such scenarios could range from minimal to highly significant.

Dietary Saturated Fat

From per capita data it can be inferred that the average U.S. citizen consumes 82 g of beef per day (44), with ground beef (42 %), steaks (20 %), and processed beef (13 %) comprising the bulk of the beef consumed (54). Ground beef, choice and prime USDA quality steaks and processed beef (frankfurters, lunch meats etc) represent some of the highest total fat and saturated fat sources found in any cuts of beef. An 82 g serving of



fatty (22 % fat) ground beef can contain 8.8 g or more of saturated fat, whereas a comparable serving of lean (2.5 % fat) grass fed beef may contain as little as 1.2 g of saturated fat. Hence a daily reduction of up to 7.6 g of saturated fat could be achieved in this scenario involving only displacement of high fat beef with lean grass fed beef

Figure 9. The exponential decline in the protein energy of various beef samples with increasing fat % by weight. Adapted from (42).

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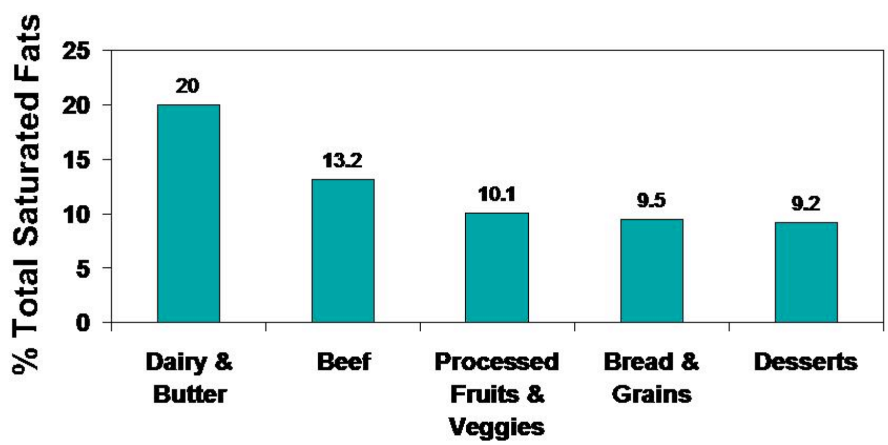
Saturated fat intakes of < 10 % total energy are recommended to reduce the risk of cardiovascular disease (55). Accordingly in a 2,200 kcal diet, saturated fat (9 kcal/g) should be limited to 24.4 g. Thus, the savings accrued (7.6 g of saturated fat) in this scenario by replacing fatty ground beef with lean grass fed beef represents a substantial 31 % reduction in total saturated fat. By employing the Howell equation [Δ serum CHOL (mg/dL) = 1.918 x ΔSAT – 0.900 x ΔPUFA + 0.0222 x ΔCHOL] (56), it is possible to calculate how changes in dietary saturated fat (SAT), polyunsaturated fat (PUFA) and dietary cholesterol (CHOL) influence blood cholesterol concentrations. This single reduction in saturated fat (7.6 g), by itself, would reduce blood cholesterol concentrations by 14.5 mg/dl. Hence borderline high blood cholesterol concentrations (200 – 239 mg/dl) could be brought into desirable ranges (< 200 mg/dl) to reduce the risk of cardiovascular disease.

The previous example represents a best case scenario when lean cuts of grass fed beef replace high fat beef cuts. Clearly, better improvements could be realized for individuals consuming more than 82 g of fatty beef. Additionally, lesser, but clinically significant improvements in the blood lipid profile could be accrued by partial replacement of fatty beef with lean beef. Finally, it goes without saying that additional servings of lean grass fed beef (above and beyond the 82 g per capita intake) that displace other high dietary sources of saturated fat such as whole milk, cheese, and processed foods would have beneficial effects upon LDL and total cholesterol concentrations. Figure 10 lists the major sources of saturated fat in the U.S. Diet (57).

Figure 10. The primary sources of saturated fat in the U.S. diet. Adapted from (57).



Dietary Protein

Because of it's inherently low fat content (2.6 % by weight), grass fed beef is also a high protein food averaging 76.5 % protein by total energy (Figure 9). Contrast these values to USDA Choice (+) beef with only 48.7 % protein by energy, or USDA Prime (o) beef with 40.8 % protein by energy, or worse still, fatty ground beef with 20.3 % protein by energy. A litany of recent human studies demonstrates that isocaloric replacement of dietary fat by lean protein has numerous health promoting effects.

Numerous short term human dietary interventions have demonstrated the therapeutic effect of lean, animal based protein upon blood lipid parameters. Wolfe and colleagues have shown that the isocaloric substitution of protein (23% energy) for carbohydrate in moderately hypercholesterolemic subjects resulted in significant decreases in total, LDL and VLDL cholesterol, and triglycerides while HDL cholesterol increased (58). Similar blood lipid changes have been observed in normal healthy subjects (59) and in type II diabetic patients in conjunction with improvements in glucose and insulin metabolism (60, 61). A litany of more recent studies has confirmed that elevations in dietary protein have a beneficial effect upon blood lipid profiles (62-68). The mechanism or mechanisms of action of high protein diets upon blood lipid chemistry are not clear; however animal studies suggest that the beneficial effects are caused by their powerful inhibition of hepatic VLDL synthesis, perhaps by altering apoprotein synthesis and assembly in the liver (69).

The relationship between protein intake and blood pressure has been comprehensively examined in observational population studies, and support the notion that higher protein intake can lower blood pressure (70-72). A substantial number of randomized controlled trials have demonstrated that higher dietary protein either from soy (73-75), mixed dietary sources (68) or from lean red meat (76) significantly lower blood pressure.

In addition to reducing CVD risk by improving the blood lipid profile and reducing blood pressure, higher protein diets have been shown to improve insulin sensitivity and glycemic control (62, 64, 67, 77-79) while promoting greater weight loss (63, 66, 67, 80, 81) and improved long term sustained weight maintenance (82, 83) than low fat high carbohydrate calorie restricted diets. The weight loss superiority of higher protein, calorie restricted diets over either calorie restricted (low fat/ high carbohydrate) diets or calorie restricted (high fat/low carbohydrate) appears to be caused by the greater satiety value of protein compared to either fat or carbohydrate (80, 83-86). Of the three macronutrients (protein, fat, carbohydrate), protein causes the greatest release of a gut hormone (PYY) that reduces hunger (86) while simultaneously improving central nervous system sensitivity to leptin (80), another hormone that controls appetite and body weight regulation.

Omega 3 Fatty Acids

Tables 2 and 3 demonstrate that grass fed beef contains higher concentrations of ω-3 fatty acids and lower concentrations of ω-3 fatty acids than feedlot produced beef. The World Health Organization and governmental health agencies of several countries recommend consuming (300-500) mg of (20:5n3 + 22:6n3) and 0.8 – 1.1 g of 18:3n3 (87). Table 2 indicates that an average 100 g sample of grass fed beef contains 39.1 mg of 18:3n3, whereas a similar sample of grain fed beef contain 12.2 mg. Hence, at current rates of beef consumption in the U.S. (82 g/day) the contribution of grass produced beef (4.9 % of recommended intake) to the 18:3n3 intake is 3.3 times greater than for grain produced beef (1.5 % of recommended intake). Although, the absolute contribution of 18:3n3 to the overall diet by either grass or grain produced beef appears modest, a more nutritionally relevant comparison involves the 18:3n3 contribution by energy. In order to achieve 25 % (160 mg) of the recommended 18:3n3 intake, it would require 482 kcal from a grass produced serving of beef, whereas to reach a similar level, it would require

1,677 kcal from grain produced beef. Hence from an energetic perspective, increased grass beef consumption could make a significant contribution to the 18:3n3 intake in the U.S. diet while not excessively increasing energy intake.

The primary biological activity and health effects of ω-3 fatty acids stem not from 18:3n3, but rather from the long chain (LC) ω-3 fatty acids (20:5n3, 22:5n3 and 22:6n3). Although dietary guidelines for recommended LC ω-3 fatty acids consumption invariably include only 20:5n3, and 22:6n3, it should be pointed out that in vivo, 100 % of 22:5n3 is converted to 22:6n3 by the liver (88). Hence, 22:5n3 from dietary sources is biologically equivalent to 22:6n3. In this regard, Tables 2 and 3 present summed values for all LC ω-3 fatty acids in grass and grain produced beef.

On average grass produced beef contains 60 mg of LC ω-3 fatty acids whereas grain produced beef contains roughly half as much (28.5 mg). Accordingly, at current levels of beef consumption in the U.S. (82 g/day) grass fed beef would contribute 20 % of the recommended LC ω-3 fatty acids while grain produced beef contributes 9.5 % of these fatty acids. Once again a more nutritionally relevant comparison is by energy. In order to achieve 50 % of the recommended LC ω-3 fatty acids (150 mg) it would require 295 kcal from a grass produced serving of beef, whereas to reach a similar level, it would require 673 kcal from grain produced beef. In summary, the concentrations of both 18:3n3 and LC ω-3 fatty acids are significantly greater in grass produced beef than in grain produced beef, and when considered on an energetic basis support the notion that increased consumption of grass fed beef could provide an important source of ω-3 fatty acids in the U.S. diet.

The case for increasing ω-3 fatty acids in the U.S. diet has broad and wide sweeping potential to improve human health. Specifically, ω-3 fatty acids and their balance with ω-6 fatty acids play an important role in the prevention and treatment of coronary heart disease, hypertension, type 2 diabetes, arthritis and other inflammatory diseases, autoimmune diseases, and cancer (87, 89).

Conjugated Linoleic Acid, Vitamin C, Vitamin E and Beta Carotene

Table 7 demonstrates that grass fed cattle accumulate ~ 1.5 times more CLA (cis-9, trans-11 18:2) in an equivalent concentration of lipid containing tissue than do grain fed cattle. In studies presenting the absolute concentration of CLA per 100 g meat sample (15, 30) the range of concentrations (11.5 – 31.5 mg/ 100 g) is approximately 100 times lower than values reported to influence health and well being in both humans and animals (90, 91). Consequently, the available evidence indicates that the minimal amounts of CLA found in either grass or grain produced beef are of little or no nutritional relevance. Similarly, as was previously mentioned, the concentrations of vitamins E (25, 37 – 40), C (40) and beta carotene (37, 40 – 42) are quite low and have negligible nutritional consequences other than to delay meat discoloration and improve shelf life (40, 92).

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Added nutritional value of grass-fed meat products
(adapted from the article posted on www.csuchico.edu/agr/grassfedbeef)

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Abstract:

Increasing consumer interest in grass-fed meat products has raised a number of questions with regard to meat quality and perceived differences between grass-fed and conventional production practices. The intent of this article is to summarize information currently available to support the enhanced nutrient claim for grass-fed meat products, as well as review the importance these specific nutrients have with regard to human health. A number of reports spanning three decades suggest forage-only diets can alter the lipid composition of meat, i.e., lower concentrations of saturated fatty acids and higher concentrations of long-chain polyunsaturated fatty acids. In addition, several studies report forage-fed meat contains elevated concentrations of beta-carotene and alpha tocopherol, as well as higher concentrations of omega-3 fatty acids and conjugated linoleic acid, all substances reported to have favorable effects on human health. Research to date would support the argument that grass-fed beef is higher in Vitamin A, Vitamin E, conjugated lenoleic acid and omega 3 fatty acids as compared to grain-fed contemporaries when lipids are compared on a gram of fatty acid/gram of lipid basis, therefore when fed to the same degree of fat, grass-fed meat products are higher in favorable lipids than conventionally produced products.

Review:

There is considerable support among the dietetic community for dietary recommendations that promote reduced fat intake, in particular, reduced intake of fat loaded with saturated fatty acids (SFAs). Saturated fatty acids have been associated with increased serum low-density-lipoprotein (LDL) cholesterol concentrations and therefore, increased risk of coronary heart disease [1]. As a result, consumers reduced their consumption of high fat foods including red meat. More recently, O'Dea et al. concluded that lean beef can be part of a cholesterol lowering diet provided it is free of all visible fat and the saturated fatty acid content of the remaining diet was kept low [2]. This was the first of several subsequent studies that suggest lean beef can be used to reduce plasma concentrations of LDL, as well as very low density lipoprotein (VLDL) in both normal and hyper-cholesterolemic subjects, thus reducing risk of coronary heart disease [2-7].

These changes to dietary intake recommendations have motivated the agricultural sector to find alternative feeding practices that reduce the concentration of SFA in meat products thereby producing a protein more in line with what the American Heart Association describes as “heart-healthy”. A number of reports spanning three decades suggest forage-only diets can significantly alter the lipid composition of the final meat product while reducing the overall fat content. In addition, several studies report that forage-fed meat contains elevated concentrations of beta-carotene and alpha tocopherol, as well as higher concentrations of omega-3 fatty acids (n-3) and conjugated linoleic acid (CLA), all substances reported to have favorable effects on human health.

Forage-fed or grass-fed beef is not a new idea. Most of the beef produced until the 1940’s was finished on forage. During the 50’s, considerable research was done to improve the efficiency of beef production, conclusively; grain feeding provided a means to finish cattle faster and with higher carcass quality characteristics which was popular at that time. Because of this efficiency, the current standard production method calls for finishing cattle on grain for the last 90 to 140 days before processing. However, changes in consumer demand, coupled with new research on the effect of feed on meat nutrient quality, have a number of ranchers returning to the old ways of production and fatten cattle all the way to processing on forages.

The purpose of this article is to summarize information currently available to support the enhanced nutrient claim for grass-fed meat products as well as review the effects these specific nutrients have on human health.

Pro Vitamin A: Beta-Carotene:

Beta-Carotene, a fat-soluble antioxidant, which belongs to a family of natural chemicals known as carotenes or carotenoids. Carotenes produce the yellow and orange color found in fruits and vegetables and is converted to vitamin A (retinol) by the body. Vitamin A is a critical fat-soluble vitamin that is important for normal vision, bone growth, reproduction, cell division, and cell differentiation [3] . Specifically, it is responsible for maintaining the surface lining of the eyes and also the lining of the respiratory, urinary, and intestinal tracts. The overall integrity of skin and mucous membranes is maintained by vitamin A, creating a barrier to bacterial and viral infection [4,5]. In addition, vitamin A is involved in the regulation of immune function by supporting the production and function of white blood cells [6,7].

The current recommended intake of vitamin A is 3,000-5,000 IU for men and 2,300-4,000 IU for women [8] which is equivalent to 900 – 1500 µg (micrograms) (Note: DRI (dietary reference intake) as reported by the Institute of Medicine for non-pregnant/non-lactating adult females is 700 µg/day and males is 900µg/day or 2,300 – 3,000 I U (assuming conversion of 3.33 IU/µg). While there is no RDA (Required Daily Allowance) for beta-carotene or other pro-vitamin A carotenoids, the Institute of Medicine suggests consuming 3 mg of beta-carotene daily to maintain plasma beta-carotene in the range associated with normal function and a lowered risk of chronic diseases (NIH: Office of Dietary Supplements).

The effects of grass or forage feeding on beta-carotene content of beef was described by Descalzo et al. who found pasture-fed steers incorporated significantly higher amounts of beta-carotene into muscle tissues as compared to grain-fed animals [9]. Concentrations ranged from 0.63 -0.45 µg/g and 0.06- 0.5 µg/g for meat from pasture and grain-fed cattle respectively, a 10 fold increase in beta-carotene levels for grass-fed beef. Similar data has been reported by Simonne et al., Yang et al., and Wood and Enser, presumably due to the high beta-carotene content of fresh forage as compared to cereal grains[10-13].

Vitamin E: Alpha-tocopherol:

Vitamin E is also a fat-soluble vitamin that exists in eight different forms with powerful antioxidant activity, the most active being alpha-tocopherol [14]. Antioxidants protect cells against the effects of free radicals. Free radicals are potentially damaging by-products of the body's metabolism that may contribute to the development of chronic diseases such as cancer and cardiovascular disease.

Preliminary research shows vitamin E supplementation may help prevent or delay coronary heart disease [15-18]. Vitamin E may also block the formation of nitrosamines, which are carcinogens formed in the stomach from nitrates consumed in the diet. It may also protect against the development of cancers by enhancing immune function [19]. In addition to the cancer fighting effects, there are some observational studies that found lens clarity (a diagnostic tool for cataracts) was better in patients who regularly use vitamin E [20,21].

The current recommended intake of vitamin E is 22 IU (natural source) or 33 IU (synthetic source) for men and women [8,22] which is equivalent to 15 milligrams by weight.

The concentration of natural alpha-tocopherol (vitamin E) found in grain-fed beef is approximately 2.0 µg/g of muscle whereas pasture fed beef ranges from 5.0 to 9.3 µg/g of tissue depending on the type of forage made available to the animals [11,23]. Forage finishing increases alpha-tocopherol levels 3-fold over conventional beef and places grass-fed beef well within range of the muscle alpha-tocopherol levels needed to extend the shelf-life of retail beef [24]. Vitamin E, alpha-tocopherol acts, post-mortem to delay oxidative deterioration of the meat, i.e., a process by which myoglobin is converted into brown metmyoglobin, producing a darkened appearance brown to the meat.

Omega 3: Omega 6 Fatty Acids:

There are two essential fatty acids (EFAs) in human nutrition: alpha-linolenic acid (ALA), an omega-3 fatty acid, and linoleic acid (LA), an omega-6 fatty acid. Both ALA and LA are polyunsaturated and serve as precursors of other important compounds. For instance, ALA is the precursor for the omega-3 pathway; all other omega-3 fatty acids are made from ALA. Likewise, LA is the parent fatty acid in the omega-6 pathway. Omega-3 (n-3) and omega-6 (n-6) fatty acids are two separate distinct families, yet they are synthesized by some of the same enzymes, i.e., delta-5-desaturase and delta-6-desaturase. Excess of one family of fatty acids can interfere with the metabolism of the other, reducing its incorporation into tissue lipids and altering their overall biological effects [25].

A healthy diet should consist of roughly one to four times more omega-6 fatty acids than omega-3 fatty acids. The typical American diet tends to contain 11 to 30 times more omega -6 fatty acids than omega -3, a phenomenon that has been hypothesized to be a significant factor in the rising rate of inflammatory disorders in the United States[26].

The major types of omega-3 fatty acids used by the body include: alpha-linolenic acid (C18:3n-3, ALA), eicosapentaenoic acid (C20:5n-3, EPA), docosapentaenoic acid (C22:5n-3, DPA), and docosahexaenoic acid (C22:6n-3, DHA). Once eaten, the body converts ALA to EPA, DPA and DHA.

The omega-3 fatty acids were first discovered in the early 1970's when Danish physicians observed that Greenland Eskimos had an exceptionally low incidence of heart disease and arthritis despite the fact that they consumed a diet high in fat. These early studies established fish as a rich source of n-3 fatty acids. More recent research has established that EPA and DHA play a crucial role in the prevention of atherosclerosis, heart attack, depression and cancer [27,28]. In addition, omega-3 consumption reduced the inflammation caused by rheumatoid arthritis [29,30].

The human brain has a high requirement for DHA; low DHA levels have been linked to low brain serotonin levels, which are connected to an increased tendency for depression and suicide. Several studies have established a clear association between low levels of omega -3 fatty acids and depression. In fact, countries with a high level of omega-3 consumption have fewer cases of depression, decreased incidence of age-related memory loss as well as a reduction in impaired cognitive function and a lower risk of developing Alzheimer's disease [31,32,32-38] .

The National Institutes of Health recently published recommended daily intakes of fatty acids; specific recommendations include 650 mg of EPA and DHA, 2.22 g/day of alpha-linolenic acid and 4.44 g/day of linoleic acid. However, the Institute of Medicine has recommended DRIs for linoleic acid (omega-6) at 12-17 g and 1.1-1.6 g for alpha-linolenic acid (omega-3) for adult women/men. Although seafood is the major dietary source of n-3 fatty acids, a recent fatty acid intake survey indicated that red meat also serves as a significant source of n-3 fatty acids for some populations [39].

Sinclair and co-workers were the first to show that beef consumption increased serum concentrations of a number of n-3 fatty acids including, EPA, DPA and DHA in humans [40]. Likewise, there are a number of studies that have been conducted in livestock which report similar findings, i.e., animals that consume rations high in precursor lipids produce a meat product higher in the essential fatty acids [40,41]. For instance, cattle fed primarily grass increased the omega-3 content of the meat by 60% and also produced a more favorable omega-6 to omega-3 ratio than conventional grain-fed beef. [12,33,42,43]. Table 1 from French et al., shows the effect of ration on n-6:n-3 ratio, data is reported as g/100 g of total fatty acids in meat produced from the various feeding regimes.

The all-grass diet produced the highest omega-3 concentration within meat while omega-6 levels stayed fairly constant regardless of grain to grass ratio. As the concentration of grain was increased, the concentration of n-3 fatty acids decreased in a linear fashion. However, at a grain:grass ratio of 1:5, the concentration of n-3 fatty acids did not differ (P>.05) from the grass-only ration.

Insert Table 1.

Rule et al. reported similar results in a direct comparison of n-6 and n-3 EFAs for cattle on grain vs. grass, i.e., grass-fed cattle produced higher concentrations of n-3 within the lipid fraction than grain-fed contemporaries, producing a more favorable n-6:n-3 ratio. (Table 2)

Insert Table 2.

The amount of total lipid (fat) found in a serving of meat is highly dependent upon the feeding regime and to some extent the genetics of the animal as well as the actual cut or anatomical area on the carcass where the cut is located. However, when lipid content is standard, grain-fed beef at 10% fat would provide 84 milligrams of omega-3 in a 100 gram serving according to French et al. [42] (.84 g n-3/100 g lipid; 100 g serving at 10% lipid = 10 g fat/serving; roughly 84 mg n-3). The same hamburger (at 10% fat) from grass-fed beef would produce 136 mg n-3/serving.

In general, grass-fed cattle are slaughtered at lighter weights than grain fed beef, producing leaner (lower fat) carcasses overall. Lean carcasses, typical of a grass-fed beef carcass is at risk for cold shortening during the aging process, a situation where the muscle fibers contract, significantly reducing tenderness and overall product quality.[44,45] Carcasses require 1/4 inches of fat cover to prevent cold-shortening.

Conjugated Linoleic Acid (CLA):

Conjugated linoleic acid (CLA) is a group of polyunsaturated fatty acids found in meat and milk from ruminant animals and exist as a general mixture of positional and geometric conjugated isomers of linoleic acid [46]. These compounds are produced in the rumen of cattle and other ruminant animals during the microbial biohydrogenation of linoleic and linolenic acids by an anaerobic rumen bacterium *Butyrivibrio fibrisolvens* [47]. In addition, there is a small amount of de novo CLA synthesis that occurs within adipose tissue [48].

Nine different positional and geometrical isomers result from this process, of which, cis-9, trans-11 is the most abundant and is considered to be the most biologically active form. Cis-9, trans-11 makes up 75% or more of the total CLA in beef [49-51].

Over the past two decades numerous studies have shown significant health benefits attributable to the actions of CLA, as demonstrated by experimental animal models, including actions to reduce carcinogenesis, atherosclerosis, and onset of diabetes [49,52,53]. A number of excellent reviews on CLA and human health can be found in the literature [47,54,55].

Insert Figure 1.

Conjugated Linoleic Acid has also been reported to modulate body composition by reducing the accumulation of adipose tissue in a variety of species including mice, rats, pigs, and now humans [56-59]. These changes in body composition occur at ultra high doses of CLA, dosages that can only be attained through synthetic supplementation and may produce ill side-effects, with the most common being of gastrointestinal origin. There have been reports of adverse changes to glucose/insulin metabolism and liver function in some animal studies depending on the dose and the isomer studied [60-64].

Natural augmentation of CLA within the lipid fraction of meat products can be accomplished by supplying the animals with rich sources of CLA precursors, i.e., linoleic (LA) and linolenic acid (LNA). Both precursors are found in lush green forages; therefore, grass-fed ruminant species have been shown to produce 2 to 3 times more CLA than ruminants fed in confinement on concentrate-only diets [42,43,65,66].

Insert Table 3.

On average, grass-fed beef will provide approximately 123 mg of CLA for a standard hamburger at 10% fat. The same hamburger produced from grain-fed beef would provide 48.3 mg. (i.e., grass-fed = 1.23 g CLA/ 100 g lipid; 12.3 mg/g lipid; 10 % lipid/serving = 123 mg CLA) (Table 3).

Maintaining the favorable lipid profile:

Maintaining the favorable lipid profile in grass-fed beef requires a high percentage of forages, the more green and fresh the forage, the higher the C18:2 alpha-linoleic and alpha-linolenic acid precursor will be available for CLA and n-3 synthesis [41,42]. Fresh forages have 10 to 12 times more C18:3 than cereal grains [67]. Dried or cured forages, such as hay, will have a slightly lower amount of precursor for CLA and n-3 synthesis. Shifting diets to cereal grains will cause a significant change in the FA profile within the intramuscular neutral lipid fraction commonly referred to as marbling [43].

In Conclusion:

Research to date supports the argument that grass-fed beef is higher in Vitamin A, Vitamin E, CLA and Omega 3 when lipids are compared on a gram of fatty acid/gram of lipid basis. Little work has been done to compare grass-fed cattle to grain-fed at a constant degree of fatness, most studies harvest cattle after a specific number of days on feed rather than processing cattle at a logical slaughter endpoint based on degree of fatness. Because grass-fed cattle are fed lower energy diets, they tend to fatten more slowly and are slaughtered at a lower percent body fat. As percent body fat decreases so does the concentration of these important lipids like CLA and omega-3 in the whole cuts of beef. Thus, research is needed to address grass finishing (feeding) practices to attain an acceptable degree of fatness, taking advantage of the potential health benefits of grass-fed beef.

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Table 1.

Table 1. Essential Fatty Acids by diet (g/100g of fatty acid)	**Treatment**				
Fatty Acid	Grass silage + 4kg grain	1kg hay + 8 kg grain	6 kg grass (DM basis) + 5 kg of grain	12 kg grass (DM basis) + 2.5 kg of grain	22 kg of grass DM
n-6 fatty acids	2.96	3.21	3.12	3.04	3.14
n-3 fatty acids	.91[y]	.84[y]	1.13[x]	1.25[wx]	1.36[w]
n6:n3 ratio	3.61[w]	4.15[w]	2.86[x]	2.47[x]	2.33[x]

[w,x,y,z] Means within rows with common superscripts are not significantly different (P>.05) French, et al., 2000.
Dry Matter (DM)

Table 2.

Table 2. EFAs by diet (as % of total fatty acids)	Grass-fed	Grain-fed
n-6 fatty acids	5.66 %[a]	3.92 %[a]
n-3 fatty acids	2.90 %[b]	0.64 %[c]
n6:n3 ratio	1.95[d]	6.38[e]

[a,b,c,d,e] Means within rows with common superscripts are not significantly different (P>.01) Rule, et al., 2002.

Table 3:

Conjugated Linoleic Acid (g/100g or g/3.50oz.)			
Study	Feedlot/Grain	Forage-fed	Amount Increased
French, 2000	.37 [a]	1.08 [b]	2.92 X
Duckett, 1993	.82 [c]	2.2 [d]	2.69 X
Rule, 2002	.26 [e]	.41 [f]	2.04 X
Realini, 2004	.25[g]	.53[h]	2.12 X
Poulson, 2004	.25[i]	.46[j]	1.84 X

Fatty Acid Profiles in Grass-Fed Beef and What They Mean

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Introduction

Fat and cholesterol are required by the human body to function everyday. Cholesterol is found in foods of animal origin and serves as a precursor to all other steroids in the body including corticosteroids, sex hormones and vitamin D. Essential fatty acids cannot be synthesized in the human body and give rise to eicosanoids including prostaglandins, thromboxanes and leukotrienes. So what's problem with fat and cholesterol in our diet? Cholesterol levels in the bloodstream are important. High cholesterol levels increase the risk for heart disease. Cholesterol can buildup in plaques inside arteries, a process called atherosclerosis, and block blood flow to the heart. This limits flow of nutrients and oxygen and can lead to heart attack or stroke if the plaques rupture. The National Cholesterol Education Program (**NCEP**) recommends for adults age 20 years and greater that total cholesterol levels be less than 200 mg per deciliter.

Dietary cholesterol consumption has little effect on blood cholesterol levels. The reason for this is due to the fact that dietary cholesterol contributes only about 25% of total cholesterol, whereas the human body produces about 75% of total blood cholesterol. A 150 mg reduction (from current U.S. average 450 mg/d to recommended level 300 mg/d) in dietary cholesterol intake will reduce blood cholesterol levels about 2% (i.e. blood cholesterol of 240 mg/dL will have a 4.8 mg/dL reduction). In contrast, medications called statins (i.e. Lipitor) reduce blood cholesterol levels by 40% (240 mg/dL x 40% = 96 mg/dL) through reductions in cholesterol synthesis.

One of the most important factors in regulating blood cholesterol levels is the type of dietary fat consumed. The type of fat consumed influences the lipoproteins that carry cholesterol in the blood. Two main lipoproteins are Low-density lipoprotein (**LDL**) and High-density lipoprotein (**HDL**). Low-density lipoprotein carries cholesterol from the liver to the rest of the body. If there is too much LDL, it can be deposited in the arteries and therefore referred to as "Bad" cholesterol. High-density lipoprotein carries cholesterol from the blood back to the liver for elimination from the body and is therefore considered "Good" cholesterol. The NCEP recommends that HDL cholesterol levels greater than 40 mg/dL and LDL cholesterol levels less than 100 mg/dL. Because the type of dietary fat consumed directly influences the levels of LDL and HDL cholesterol in the blood, one must alter the type of dietary fat intake in order to make significant changes in blood cholesterol levels.

Fat and Cholesterol

Fatty acids are characterized and typed by the number of carbons, number of double bonds, double bond location and configuration. The main types of fatty acids are: saturated, trans, monounsaturated, and polyunsaturated. Saturated fatty acids (**SFA**) raise total blood cholesterol levels; however, not all saturated fats are equal. One saturated fat called stearic acid (C18:0) does not elevate blood LDL cholesterol level and is considered neutral. Consumption of diets rich in shorter-chain, saturated fatty acids like lauric (C12:0), myristic (C14:0), and palmitic (C16:0) acids increase blood LDL-cholesterol and are considered cholesterol-elevating or hypercholesterolemic.

Trans fatty acids are receiving attention lately and are even being banned from the menu in some U.S. cities. Trans fatty acids are produced during the hydrogenation of unsaturated vegetable oils (40-60% of total fatty acids as trans) and are found in margarines or processed products that list partially hydrogenated vegetable oil in the ingredient list. This process of hydrogenation increases shelf life of the oil by reducing polyunsaturated fatty acid levels. In this process, many short chain trans fatty acids are produced (trans bonds in 6-16 position) and consumption of these artificial trans fatty acids increases bad (LDL) cholesterol and decreases good (HDL) cholesterol. Results from the Nurses' Health Study found that women who consumed 4 teaspoons of margarine containing artificial trans fat had a 50% greater risk of heart disease than women who ate margarine only rarely (Willet et al., 1993). Mensink and Katan (1990) compared the effects of a trans or saturated fatty acid rich diet in humans and demonstrated that trans fats have a more negative effect on serum cholesterol levels than saturated fats. Clifton et al. (2004) reported high correlations (r = 0.66) between dietary trans fat intake from margarine and level of trans fat in adipose tissue, and that the level of trans fat in adipose tissue was associated with increased risk of coronary artery disease.

Ruminant animal products (beef, lamb, butter, ice cream, cheese, etc.) also contain low levels (1-8% of total fatty acids as trans) of trans fatty acids. These trans fatty acids are produced naturally during the biohydrogenation of unsaturated fatty acids in the rumen. These naturally produced trans fatty acids (trans bonds predominately in 9-11 position) are receiving distinction from their artificial counterparts present in partially hydrogenated vegetable oil. One reason for this is that the major trans fatty acid in most ruminant products is vaccenic acid (C18:1 t11; **VA**), which can be converted to conjugated linoleic acid (**CLA**) and has cancer-fighting properties. Turpeinen et al. (2002) reported that on average 19% of dietary VA is converted to CLA, cis-9 trans-11 isomer, in humans. As a result, it has been suggested that dietary consequences of VA in beef products should be considered separately from other trans fatty acids (Lock et al., 2005).

Monounsaturated fatty acids (**MUFA**) contain one, cis double bond. Oleic acid (C18:1 c9), a MUFA, is the predominant fatty acid in ruminant animal products and comprises from 30-50% of the total fatty acids present. Consumption of diets rich in monounsaturated fatty acids increases good (HDL) and lowers bad (LDL) cholesterol levels (Mensink and Katan, 1989). Canola and olive oils contain predominately MUFA at levels of 58% and 72% of total fatty acids, respectively.

Polyunsaturated fatty acids (PUFA) are subdivided into two categories, omega-6 and omega-3, based on location of the double bonds in the fatty acid chain. Omega-6 fatty acids are common in grains and vegetable oils. Omega-3 fatty acids are common in plant lipids and fish oils. Diets containing omega-6 or omega-3 fatty acids lower blood total and LDL cholesterol; however, omega-6 PUFA also tend to lower HDL cholesterol (Mensink and Katan, 1989). Consumption of diets high in omega-3 fatty acids is associated with reduced risk of heart disease, stroke and cancer (Kris-Etherton et al., 2002). Currently, Americans consume greater amounts of omega-6 PUFA than omega-3 PUFA, which has dramatically altered the omega-6 to omega-3 ration in the human diet. Health professionals recommend that we consume a diet with a more balanced ratio (< 4:1) of omega-6 to omega-3 PUFA. The World Health Organization recommends a daily intake of 1.1 g/d of omega-3 fatty acids with approximately 0.8 g/d of linolenic acid and 0.3 g/d of EPA and DHA.

Cancer-Fighting Compounds

In cattle, dietary unsaturated fatty acids are biohydrogenated (BH) in the rumen to saturated end products. However, this process of ruminal BH is sometimes incomplete yielding various trans-octadecenoic acids and conjugated linoleic acid (CLA) isomers. Conjugated linoleic acid, specifically the cis-9 trans-11 isomer, has been shown to possess anticarcinogenic effects (Ha et al., 1987). Evidence from in vitro and rodent experiments suggests that a minimum dietary level of 0.5% CLA cis-9 trans-11 isomer is needed to help reduce the incidence of cancer (Ip et al., 1994). If the average American adult consumes a 2200 kcal diet with about 40% of calories from fat (assuming 60% diet digestibility), we estimate that the average dietary intake for adults would be about 600 g per d and the level of CLA needed would be 300 mg of CLA cis-9 trans-11 per d. Beef products in the human diet are reported to contribute about 25% of total dietary CLA with dairy products as the primary sources (Ritzenthaler et al., 2001). Research now shows that over 80% of the CLA present in milk (Griinari et al., 2000) and beef (Gillis et al., 2003) is formed by desaturation of VA to CLA cis-9 trans-11 in mammary and adipose tissues. In humans, estimates are that about 19% of VA from enriched butter is desaturated to CLA cis-9 trans-11 isomer with ranges from 0 to 30% (Turpeinen et al., 2002). Thus, levels of both CLA and VA in beef products are important in determining the potential levels of CLA in humans.

Grass-fed Beef

Fatty acid composition as a percentage of total fatty acids of beef muscle from concentrate-finished versus grass-finished beef is shown in Table 1. The results are from the Appalachian Pasture Beef Systems Project and data was collected on 200 Angus-cross steers for a period of three years (Sonon et al., 2005). Steers (12 mo of age) were finished on either concentrate/corn silage diet in the feedlot or on pasture for 150 d. Steers on pasture treatment grazed “naturalized” pasture, which consisted of a mix of bluegrass, orchardgrass, endophyte-free tall fescue and white clover for majority of the time and hay meadow regrowth and triticale for short periods of time Steers were fed to an equal age in order to minimize confounding due to animal age or environmental factors. The percentage of SFA, odd-chain, or omega-6 PUFA did not differ between concentrate and grass finished beef. Monounsaturated fatty acid percentage was greater for concentrate than grass-finished. Omega-3 PUFA percentage was greater for grass- than concentrate-finished. This resulted in a lower, more desirable, ratio of omega-6 to omega-3 fatty acids in grass-finished beef (1.65) compared to concentrate-finished beef (4.84). The percentage of CLA, cis-9 trans-11 isomer, was greater for grass- than concentrate-finished. Vaccenic acid percentage was also greater for grass- than concentrate-finished beef.

Fatty acid content (g per 3 oz. serving, broiled) of beef muscle from concentrate-finished versus grass-finished beef is shown in Table 2. Grass-finished beef contains half (2.1 g/serving) of total fatty acids compared to concentrate-finished beef (4.2 g/serving). Due to these differences in total fatty acid content of beef, the fatty acid composition on a per serving basis (3 oz. broiled) is also changed. Saturated fat content was lower for grass-finished than concentrate-finished beef. The amount of odd-chain and MUFA per serving was lower for grass-finished than concentrate-finished beef. Omega-6 PUFA content was lower and omega-3 PUFA content was higher for grass-finished than concentrate-finished beef. Because the percentage of CLA, cis-9 trans-11 isomer, in grass-fed was twice as high but total fatty acid content was half that of concentrate-finished, the amount of CLA per serving is similar among concentrate- and grass-finished beef. However, the amount of VA is 4-fold higher for grass-fed beef and this can be desaturated to CLA in the human body. Cholesterol content per serving did not differ among finishing systems. Overall, grass-fed beef produced from animals of the same age as concentrate-fed beef will have lower total, saturated, and monounsaturated fatty acid content with greater omega-3 fatty acid and vaccenic acid content.

Forage Species

The fatty acid composition of beef produced from finishing on various forage species versus concentrate finished beef is shown in Table 3. These results are from the Appalachian Pasture Based Beef Systems Project and represent 47 Angus-cross steers finished in fall of 2005 (Duckett et al., 2006). This project is on-going and additional data will be collected for another two-year period. Thirty-six steers (12 mo of age) grazed native pastures consisting of bluegrass and white clover for 110 d and then were randomly allotted to grazing paddocks containing alfalfa, pearl millet or native pastures. Steers grazed these paddocks containing the three forage species for an additional 40 d. Twelve steers were also finished on concentrate/corn silage diet for 150 d.

The percentage of SFA was greater for Native and Alfalfa-finished than concentrate-finished beef. Monounsaturated fatty acid percentage was greater for concentrate than forage finished, regardless of forage species. Omega-3 PUFA, CLA, and VA fatty acid percentages were greater for forage finished, regardless of forage species, than concentrate-finished. Ratio of omega-6 to omega-3 fatty acids was lower (1.3), more desirable for forage finished, regardless of forage species, compared to concentrate finished (6.4). Total fatty acid content was lower (2.5 g/serving) for forage-finished, regardless of forage species, compared to concentrate finished (6.0 g/serving). Cholesterol content did not differ among finishing systems. Overall, finishing on different forages resulted in minor changes in fatty acid composition.

Supplementation on Grass

Fatty acid composition of beef finished on endophyte-free tall fescue pasture only (PAST), pasture + 0.52% of BW (DM basis) corn grain (PAST-CORN) or pasture + 0.1% corn oil + 0.42% soybean hulls (PAST-OIL), compared to high concentrate grain finishing (15% grass hay; 85% concentrate; CONC) are shown in Table 4. Twenty-eight Angus steers were randomly allotted to three pasture treatments with or without supplementation for 197 d (Pavan and Duckett, 2006). Concentrate finished steers were allowed to graze endophyte-free tall fescue for 105 d and then were finished on a high concentrate diet for 92 d. Steers were slaughtered at a similar age endpoint to minimize confounding due to animal age or environment.

Saturated fatty acid percentage was higher for PAST-OIL and CONC than PAST. Monounsaturated fatty acid percentage was highest for CONC and lowest for PAST and PAST-OIL. Oil supplementation on pasture (PAST-OIL) increased the omega-6 fatty acid percentage in beef muscle to 8.8%, levels greater than PAST or PAST-CORN. Omega-6 fatty acid percentage was also greater for PAST and PAST-CORN than CONC. Omega-3 PUFA percentage was highest for PAST and lowest for CONC. Corn grain or oil supplementation lowered the percentages of omega-3 PUFA compared to PAST but levels were greater than CONC. The ratio of omega-6 to omega-3 ratio was lowest for PAST. Supplementation of corn grain or corn oil on pasture resulted in higher omega-6 to omega-3 ratios. Conjugated linoleic acid and VA concentrations were highest for PAST-OIL and lowest for CONC. Supplementation with corn grain on pasture lowered CLA and VA percentages compared to PAST but levels were greater than CONC. Total fatty acid content was greater for CONC than PAST-OIL, which were both greater than PAST or PAST-CORN. Cholesterol content did not differ among dietary treatments. Overall, oil supplementation on pasture increased CLA and VA concentrations; however, oil supplementation also increased omega-6 PUFA resulting in a high ratio of omega-6 to omega-3 PUFA. Corn grain supplementation on pasture reduced levels of CLA, VA and omega-3 PUFA compared to pasture only.

Summary

Grass-fed beef contains greater concentrations of conjugated linoleic acid, vaccenic acid, and omega-3 PUFA than concentrate-fed beef. Grass-fed beef also contains lower total fat content when finished to similar time endpoints. This reduction in total fat content results in lower saturated fat, monounsaturated fat, and omega-6 PUFA content in one 3 oz. serving of grass-fed beef. On a per serving basis, conjugated linoleic acid content is similar among grass-fed and concentrate-fed beef but vaccenic acid, which can be converted to conjugated linoleic acid, content is 4-fold greater for grass-fed. Omega-3 PUFA content per serving is higher; however, levels are low (45 mg/serving) compared to other sources of omega-3 PUFA (chinook salmon, 1821 mg/serving; bluefin tuna, 1415 mg/serving). Finishing cattle on various forage species appears to results in minor changes in fatty acid composition. Supplementation on pasture alters fatty acid composition depending on the type and amount of supplement offered.

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Table 1. Fatty acid composition (% of total fatty acids) of ribeye steaks from concentrate- or grass-finished beef (Sonon et al., 2005).

Fatty acid, % of total fatty acids	Concentrate-finished	Grass-finished
n	103	95
Saturated	43.44	44.24
Odd-Chain	1.79	1.74
Monounsaturated	41.99[a]	33.97[b]
Polyunsaturated, omega-6	3.71	3.77
Polyunsaturated, omega-3	0.79[b]	2.32[a]
Ratio omega-6:omega-3	4.84[a]	1.65[b]
Conjugated Linoleic Acid, cis-9 trans-11	0.36[a]	0.78[b]
Vaccenic acid	0.32[a]	3.34[b]

[ab]Means in the same row with uncommon superscripts differ ($P < 0.05$).

Table 2. Fatty acid content (g/3 oz. serving, broiled) of ribeye steaks from grain-or grass-finished beef.

Fatty acid, g/3 oz. serving, broiled	Concentrate-finished	Grass-finished
n	103	95
Total fatty acid content	4.16[a]	2.13[b]
Saturated	1.82[a]	0.95[b]
Odd-Chain	0.073[a]	0.037[b]
Monounsaturated	1.76[a]	0.73[b]
Polyunsaturated, omega-6	0.142[a]	0.074[b]
Polyunsaturated, omega-3	0.032[b]	0.045[a]
Conjugated linoleic acid, cis-9 trans-11	0.016	0.017
Vaccenic acid	0.014[a]	0.072[b]
Cholesterol, mg/3 oz. serving	64.17	65.29

[ab]Means in the same row with uncommon superscripts differ ($P < 0.05$).

Table 3. Fatty acid composition of beef finished on three different forages species or a high concentrate diet (Duckett et al., 2006).

Fatty acid, % of total	Native	Alfalfa	Pearl Millet	Concentrate
n	12	12	12	11
Saturated	46.60[a]	47.42[a]	45.72[ab]	44.16[b]
Odd-Chain	1.55	1.51	1.47	1.59
Monounsaturated	35.24[b]	35.91[b]	37.18[b]	44.68[a]
Polyunsaturated, omega-6	3.43	3.66	3.39	3.14
Polyunsaturated, omega-3	2.55[a]	2.81[a]	2.56[a]	0.56[b]
Ratio omega-6:omega-3	1.34[b]	1.29[b]	1.32[b]	6.37[a]
Conjugated linoleic acid, cis-9 trans-11	0.67[a]	0.65[a]	0.68[a]	0.26[b]
Vaccenic acid	3.15[a]	2.83[a]	2.82[a]	0.12[b]
Total fatty acids, g/serving	2.54	2.66	2.22	6.03
Cholesterol, mg/serving	66.21	62.78	64.54	64.26

[ab]Means in the same row with uncommon superscripts differ ($P < 0.05$).

Table 4. Fatty acid composition of beef finished on pasture with or without corn grain or corn oil supplementation compared to concentrate-finished beef (Pavan and Duckett, 2006).

	Pasture	Pasture + Corn	Pasture + Oil	Concentrate
n	7	7	7	7
Saturated	39.69[b]	41.38[ab]	42.34[a]	42.76[a]
Odd-Chain	1.61	1.33	1.15	1.74
Monounsaturated	33.25[c]	36.42[b]	30.65[c]	43.04[a]
Polyunsaturated, omega-6	6.22[b]	6.53[b]	8.78[a]	3.54[c]
Polyunsaturated, omega-3	4.16[a]	2.61[b]	1.79[c]	1.08[d]
Ratio omega-6:omega-3	1.49[d]	2.49[c]	4.95[a]	3.27[b]
Conjugated linoleic acid, cis-9 trans-11	0.92[b]	0.62[c]	1.14[a]	0.36[d]
Vaccenic acid	2.83[b]	2.04[c]	5.40[a]	0.95[d]
Total fatty acids, g/serving	1.73[c]	1.95[c]	2.52[b]	4.62[a]
Cholesterol, mg/serving	59.98	60.02	59.74	63.70

Aging the Beef for Tenderness and Flavor
How much is enough?

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Introduction:

Beef carcasses or cuts are aged in order to improve tenderness and sometimes to impart a distinctive aged meat flavor. The fundamental mechanism for improvement of tenderness is degradation of structural proteins by endogenous enzymes. Protein degradation in the muscle requires considerable time so aging is done over a period of days or weeks. In the normal scheme of production beef sub-primals are vacuum packaged and held under refrigeration during storage and distribution. Aging processes proceed in this beef until the meat is frozen or cooked. Thus, so called "Wet Aging" is a normal occurrence for nearly all fresh beef. In some cases beef carcasses or cuts are held in refrigeration without any packaging for so called "Dry Aging". Dry aging leads to improved tenderness as well as development of aged meat flavor. While dry aging is carefully controlled, most of the beef industry allows wet aging to happen without much thought or planning. More or less aging time is determined by current market demand for beef. In times of high demand beef sells quickly and aging time is short. When demand is low the beef is aged longer. The result is increased variability in tenderness and a missed opportunity to improve product consistency.

Background:

At the completion of the slaughter operation the warm beef carcass is moved to a meat cooler equipped to chill the carcass to less than 40 F in 24 hours or less. During this time the muscle undergoes physiological and physical changes known collectively as rigor mortis. Over time (12-18 hours) the energy stores in the muscle become depleted with the muscle contracting slightly as the supply of energy runs low. Rigor mortis is characterized by shortening of muscle contractile apparatus leading to development of isometric tension. At the completion of rigor mortis the contractile apparatus of the muscle locks in place. The degree of shortening that occurs is determined largely by the muscle's skeletal attachments and the position of the skeleton especially the limbs during onset of rigor mortis. A greater degree of shortening is associated with a decrease in tenderness.

As rigor mortis nears completion other changes are slowly beginning to occur. Proteolytic enzymes in the muscle are beginning to attack some of the structures that make up the contractile apparatus. This process is rather slow but eventually leads to increased tenderness. The higher temperature of the carcass following slaughter facilitates the action of tenderizing enzymes. However, rapid chilling is needed to control microbial growth and is generally considered more important than tenderization.

The enzymes in muscle that are responsible for meat tenderization during aging are part of a system of enzymes that function in the normal growth, repair and remodeling of living muscle. In living muscle these enzymes function to degrade existing protein structures on an ongoing basis. In postmortem muscle enzymes may continue to function for some time especially if temperature, ionic and pH conditions are favorable. A temperature above freezing is required with higher temperatures leading to faster enzymatic action. The presence of specific ions such as calcium may be required for the action of certain enzymes. Many of the enzymes involved in protein degradation work best at the neutral pH found in living muscle. In postmortem muscle the pH is reduced from neutral down to about pH 5.7. In this more acidic environment the enzyme action may be slowed or nearly stopped.

Muscle growth depends on presence of enzymes that degrade protein structures. Muscle that is growing rapidly must have a large complement of such enzymes. Thus, muscle from rapidly growing animals might be expected to have greater capability for protein degradation and improved tenderness during aging. The current feeding practices used for grain-fed beef in the US generally lead to rapid growth and associated meat tenderness. When grass-fed beef is managed to achieve high growth rate similar levels of tenderness may be attained.

Proteolytic enzyme function declines over time as the enzymes themselves are degraded. As a result, tenderization during aging becomes progressively slower with each passing day. After 3 or 4 weeks of aging additional tenderization is quite limited. On the other hand tenderization during the first week of aging is usually most rapid so that much of the tenderness benefit can often be realized with 7-10 days of aging.

Tenderness of beef is determined by protein structures of the contractile apparatus and connective tissue in the muscle. The contractile apparatus inside muscle cells and connective tissue in the spaces among muscle cells both offer resistance during chewing. The degree of resistance is perceived as tenderness or toughness. For the contractile apparatus contraction during rigor mortis and subsequent protein degradation during aging combine to determine tenderness/toughness of this component. The contribution of connective tissue to tenderness/toughness is determined by the amount of connective tissue and the presence of intermolecular cross-links within the connective tissue. Connective tissue content varies from one cut to another while intermolecular cross-links increase in number and strength as the animal grows older. Postmortem aging does not have a great impact on muscle connective tissue.

Aging Process:
Beef protein degradation by endogenous enzymes likely proceeds immediately following completion of rigor mortis at 12-18 hours after slaughter.

At 24 or 48 hours after slaughter the beef carcass is fabricated into subprimal cuts which are typically vacuum packaged and boxed. If dry aging is to be conducted the cuts to be aged, usually ribs or loins, would be directed to an aging room without any packaging. In some operations the whole carcass might be dry aged but this practice is not common since it is not beneficial for thin cuts and shoulder cuts that may be used for ground beef. The aging will continue in the meat until freezing or cooking stop the process.

The duration of the aging process determines the outcome. For ribs and loins the rate of tenderization is most rapid during the first few days following slaughter and continued aging gives progressively less benefit as time goes on. For beef of Choice or higher grade 10 days aging time gives most of the tenderness benefit that can be achieved. The same cuts from a Select grade carcass tenderize more slowly during aging. Select grade cuts may benefit more from extended aging time or 21 or 28 days.

Wet Aging - practiced by nearly all of the beef industry. Cuts are vacuum packaged and kept under refrigeration. Protein breakdown proceeds. Meat becomes more tender. The vacuum limits microbial growth. Eventually anaerobic or microaerophilic bacteria become established and product lactic acid and other by products that affect flavor and aroma of the packaged meat. These flavor changes are very slow to occur and not offensive until very late in the process – after as much as 70 - 90 days of storage.

Dry Aging - Dry aging as a normal part of beef processing disappeared with the widespread adoption of boxed beef in the 1970's. In the beef industry today dry aging is a specialty process with limited volume but high value added. For dry aging rib or loin cut are stored at 34-38 F in open air. Air movement is maintained in order to keep the surfaces somewhat dry in order to limit spoilage. The surface of the cut becomes dehydrated and darkened. Some microbial growth occurs on the surface. Microbial degradation of fat and protein contribute to the distinctive flavor of dry aged beef. When preparing steaks after aging, the dried, discolored surface is trimmed off and discarded. Yield loss is significant. However, cuts selected for dry aging are usually from higher grade carcasses with thick fat cover. In this case the discarded part is largely fat that was already destined to be removed.

Palatability Effects of Aging:
There is little doubt about tenderness benefits from aging when tenderness is evaluated using Warner-Bratzler shear measurements. Gruber et al (2006) found that aging for up to 28 days reduced shear force in 16 of 17 different muscles from all parts of the beef carcass. However, the degree of tenderization was quite variable with *Longissimus Dorsi* and *Semimembranosus* improving by 2.5 and 2.3 kg respectively while most muscles experienced a 1 – 1.5 kg reduction in shear force. In spite of these consistent shear force

improvements consumers don't always recognize changes in tenderness when other factors like flavor are changing as well. Using randomly selected consumer panelists to evaluate wet and dry aged steaks, Sitz et al. (2006) reported that consumers rated flavor, juiciness and tenderness higher for wet aged versus dry aged USDA Prime steaks. This is in spite of the fact that some consumers pay a considerable premium for dry aged beef in part because of its preferred flavor. One might speculate that had panelists been screened based on their familiarity with dry aged beef the results might have been very different.

Recommendations for Aging Grass-Fed Beef:

Avoid rapid chilling of the carcass following slaughter to minimize the occurrence of cold shortening in muscles with minimal fat cover.

Age for 20 days or more before freezing or cooking. The greatest improvement in tenderness during aging occurs in the loin muscle (rib eye and loin eye). Don't age thin cuts or cuts that will be used for ground meat. Use wet aging except in special cases (see next item).

Use dry aging only for loin and rib primal cuts. Dry aging helps develop flavor but leads to surface microbial growth and loss of weight. It should only be used for those cuts that can benefit the most from unique flavor. Do not apply dry aging to the whole carcass.

Consider using a combination of dry and wet aging. Dry age selected cuts (loins and ribs) for two weeks to develop flavor then cut, trim and vacuum package for an additional 1-2 weeks of wet aging for tenderness.

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Holistic Approach to Animal Health and Well-Being

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Animal disease prevention or animal wellness promotion? What do these phrases bring to mind? The first seems to focus on diseases, while the latter focuses on the well-being and health of the animal. The latter is what livestock producers need to think about in order to be most profitable with optimal production.

Animals don't have to get sick. Looking at the whole farm, instead of just the animals, gives the opportunity to observe the interactions between soil, plants, animals, weather and recognizing the changes that occur when any of one of those components changes. Diseases are more than just infectious, but include anything that adversely affects the health of an animal.

I never expect my livestock to get sick. I look at the whole farming system, using the animals as my gauge to how well I'm managing the whole system. I also know the problems I have to be aware of with the system. This can be things like running out of pasture because of drought conditions, calving problems if a bull throws too large of calves, parasites in sheep and goats.

So first start out by walking the whole farm. Yes, that's right, walk the whole farm. Look at everything, including the livestock. What does it look like as a single entity? Are the livestock contented and performing to the producers' satisfaction? What do the grasses and other pasture plants look like? Are they desirable plants? Are they strong looking or yellowed and weak? Are there bare spots in pastures or is there good ground cover? Are some pastures in better shape than others or are they all uniform? Are they overgrazed or undergrazed? What color is the soil? Grab a handful and smell it. Does it have a good earthy smell? Understand what is going on with your farm.

At this point, the producer needs to focus more in on the livestock, looking at individual ones to see how healthy they look. As the producer walks closer to livestock, their behavior should change, depending on how used they are to being approached. They should all start to look at the person walking towards them and many will go ahead and stand up. In fact, animal behavior is something that every livestock producer should spend time learning. Walking amongst the herd or flock on a daily basis teaches what normal behavior is. Remembering that these are prey animals and how important the herding instinct along with group behavior is.

Notice how bright and alert they seem, how slick the hair coat looks, how full the rumen is. The latter is really important as it tells how well the animal is eating. This lets the producer know how well he/she is doing providing adequate pasture or other feeds as well as how well the animal is doing. A full rumen means a healthy ruminant. Quickly look at body condition of animals.

Then, and only then, look for animals with problems. First check for animals that are not showing the normal behavior of herd mates. Which ones aren't looking at you? Are some lagging behind or off by themselves? These should be checked out carefully. If the herd is standing, check those that are still lying down. As livestock are observed more frequently, they become calmer and more relaxed. Those lying down may have nothing wrong with them, but walking over to them and checking is important.

By walking the farm and through the livestock, the producer learns what is normal and healthy. This gives producers an important tool in determining what changes need to be made in the whole farm to ensure continued good health and wellness. Health and wellness occur through good nutrition and low stress. Attention to nutrition, especially through controlled grazing, along with reduction of stress provides the best preventative strategies. As producers become more skilled in the management of their farms, they see the health of the whole system improve.

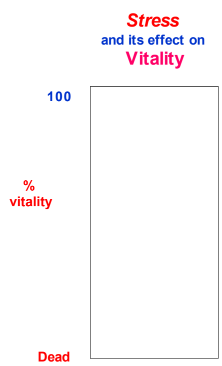
Controlled grazing is the best way for livestock to get the nutrients necessary to keep them healthy. The challenge in controlled grazing is to provide a high availability of quality forage to animals at all times. The resulting high nutritional status helps prevent many diseases that might necessitate the need for antibiotics. Controlled grazing also satisfies the natural behavior of the cattle, thus reducing stress.

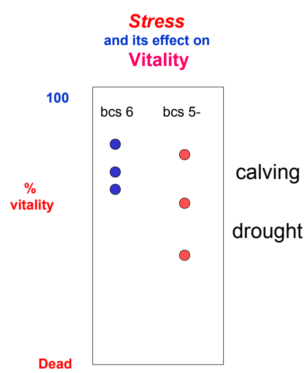
When stress is minimized, then animals remain healthier. This improves the profitability of the farm, by reducing the need for disease treatment. This makes it especially important to observe animals closely, and to provide them with the best nutrition possible through high availability of quality pasture.

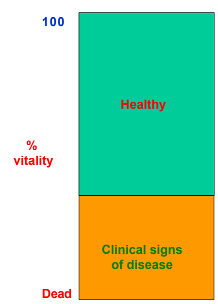
Stress is the effect of change on an animal. It increases the susceptibility to disease and decreases the vitality or life force of the animal. There are two ways of looking at the effect of stress on an animal. Stress acts upon the body setting up an imbalance**.** The body produces a reaction that may give rise to symptoms in its attempt to regain equilibrium. This means that the producer needs to look for that first symptom, or change in the animal's behavior, to prevent the animal from progressing into a full blown disease process. These symptoms may be subtle, and if the stress is mild, may be corrected by another change in the animal's behavior.

The second way to look at the effect of stress on the animal is to view the physiological changes. These changes are different depending on whether or not the animal is undergoing an acute, short term stress, or a chronic stress. Chronic stresses can be constant or intermittent. Intermittent chronic stress is much harder on the animal, as the animal just begins to recover when the same or different stress occurs. Acute stress causes the flight or fright syndrome to occur. Adrenaline is released, along with a small amount of corticosteroids. This kind of reaction indicates the animal is in control and can be seen as a good thing. Chronic stress causes release of corticosteroids which take a long time to clear from the animal's body and indicate that animal has no control over its situation. Rumination and digestion stop, which also stops growth and reproduction. The white blood cells decrease in number and the lymph tissues shrink in size. As a result the animal is less able to fight off disease and its vital force goes down.

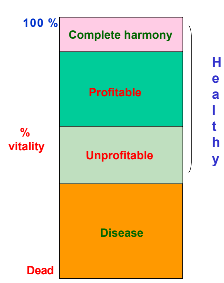
No one living has 100% vitality. There are too many external forces that affect it at least a little. If you have 0% vitality, you are dead. At some point on the vitality scale, there is a point that clinical signs of disease start showing up. Above that point, we think of the animal as having some degree of health--the mind and body being in harmony with its environment. Any stress lowers that level of vitality and weakens the harmony, until, for that animal the vitality reaches a low enough point that disease shows up. Every animal will be affected by different stresses differently. Nutrition, feeds, exposure to bacteria or other disease causing agents, reproductive status, age all have an effect, but not an equal effect on all animals. This is why one animal will get sick and not another one.

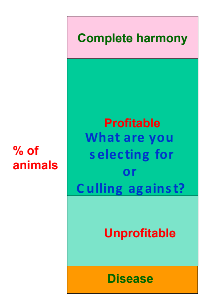






When we treat the disease, and cause the signs to disappear, but don't take care of the underlying stress, we will have a less vital animal. In this case, the animal appears healthy, but isn't. So then, let's divide health into profitable health and unprofitable health. The animal's vitality has to be brought up to a level that achieves profitable





health.

You can see that treating sick or otherwise unhealthy animals, even successfully makes no money for the farmer. It is a salvage operation. We need to start thinking of what stresses on in our herds and how we can avoid as many of them as possible. Any stress will increase the susceptibility to disease. But certain things will help the animal counteract stress better. Nutrition is the most important thing, followed by the animal's environment. It is also most economic to work on animals that are unprofitable but not "sick". And remember that any treatment may help, but the degree to which it helps depends on where the animal is on the line of % vitality. If they aren't fed well, too crowded, dirty place to sleep, too pulled down from calving, or weathers too stressful, then they won't be profitable.

Animals that are getting an abundance of protein, without adequate fiber or energy to use that protein will not be as vital. Metabolic changes will occur, in the body's attempt to provide the energy, which will be a stress on the body. This stress will allow other conditions, usually internal parasites, to show up, that the animal's immune system would otherwise be keeping under control if its nutritional status were better.

Nutrition and environmental stresses are easier to control than some other. Psychological and other behavioral stresses are harder to measure and determine. Low-stress weaning and handling techniques affect behavior in a positive way which minimizes problems. This includes treatment of sick animals. Research shows us the interaction between the animal and the treatment; how that treatment actually impacts the disease for which it is being used. It leaves out the animal-human part of that equation that also is a big factor in the health of that animal. Our thoughts and our actions affect the way our animals respond to any kind of stress and treatment. Farmers who use controlled grazing management, and thus are moving their animals frequently will have calmer animals in any handling situation.

The immune system's function is to ward off disease causing agents. Because of the destruction to it whenever the animal is under stress, this impairs its ability to fight and kill them. This is especially true when there are too many acute stresses or continuous, low-level, chronic stresses.

Stress alters the rumen microbes, which slows or stops rumination. This reduces dry matter intake, which means the animal has to use its body reserves to meet its energy requirements. If the stress is short-term, the animal will be able to overcome these affects on its own, with no apparent problems appearing. If the stress is longer lasting or chronic, returns in a short period of time or there are multiple stresses on the animal, this may throw the animal below that threshold between health and disease. For example, a first calf heifer is not only undergoing the stresses of pregnancy, calving and lactation, but also is still growing herself. These are all physiological states for which she evolved.

However, if there is inadequate or poor quality forage or feed available, rough handling or weather extremes occurring, these additional stresses may be too much for her body to compensate.

The animal's response to any new stress can decrease or disappear depending on how it is dealt with. If weather extremes occur gradually, for instance, the animal is able to adapt to the change in temperature and will not be as adversely affected. How handling, hauling or other new situations happens the first time will determine how well the animal reacts subsequently to those things.

Keep in mind that, in the winter, wind chill is more of a factor than the cold. Windbreaks are crucial to keep the stress level down, to provide for more animal comfort and thus, prevent respiratory disease outbreaks. During hot weather, shade can be a factor to consider. The number of days of a heat index over 75 degrees should be known in order to determine how big a factor shade will be for the animals. Once again, if that heat index is reached gradually, the animals will be able to adapt to a certain extent. Feed intake and reproductive failure are the two big problems with heat stress. Even extreme heat and cold, if they occur gradually enough, will not cause the same amount of stress as sudden changes in cold or heat. The animal is able to adjust to the temperature change, even though some decrease in feed intake will still occur.

Other stresses to keep in mind and develop ways of minimizing them are livestock handling, introduction of new animals, chronic disease, weaning, parasites and even antibiotics. Most of these can be managed quite easily. Antibiotics kill the beneficial bacteria along with the disease causing bacteria. These beneficial bacteria take time to replenish following a course of antibiotics, which is a stress on the animal. This is just one good reason to keep antibiotic usage to a minimum. Keeping animals healthy makes antibiotic usage rare. Weaning stress can be composed of nutritional stress, environmental stress and respiratory stress, all of which can be alleviated through pasture weaning. Parasite stress can be alleviated through integrated parasite management involving the animal, soils, pasture and weather. For example, evidence now points to grazing plants high in bypass protein decrease the impact of internal parasites. Pasture management strategies can also be used as IPM. When grazing management improves, the health of the soils and pastures improve but also the health of the animal.

When an animal gets sick, get in the habit of thinking back over the last 2 weeks to determine what stress has occurred. Some will be possible to remedy. Others, such as weather, have to be lived with. There are some diseases or conditions that will totally overwhelm the animal's defenses for which there is little the farmer can do or prepare for. Once again, having the animal at a peak nutritive level is the best defense in this case.

By focusing on animal wellness promotion, we can keep our livestock healthy. We are better prepared for problems when they do occur. The problems are also usually small.

We can spend our time and money improving the system instead of dealing with disasters. This results in a healthy profitable farm, producing healthy food for people everywhere.

Liability Issues for Direct Marketing Grass Fed Meat

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Risk management is an important area of consideration in any business. Two methods of minimizing risks are purchasing the right insurance coverage and business risk analysis and management. Most beef producers hold large amount of assets (mostly in land) that could be at risk, if a claim is filed against the operation. Diversification to direct marketing of meat products to consumers can add additional risks that need to be properly addressed to protect the assets of the ranch. Producers need to consider conducting a risk analysis of selling a food product to consumers. Most producers have assumed that the farm or ranch liability policy will cover this extended ranch business. Most insurance agents have stated that their general farm liability packages do not cover processed foods or off farm retail activity. In these cases, the policy does not provide product liability coverage that producers need if they are selling meat products to the public. Having on farm sales, farm tours, or farm stays that brings the public on the ranch to sell product, may require a business liability policy. Some farmers markets will require product and business liability policies and may also ask that they are listed as "Additional Insured".

It is best to work with your insurance agent to properly insure your business based on its operation and the risks involved. The agent needs all applications and supplements to be completed with as much detail as possible, to satisfy the insurance underwriters. The insurance industry operates on a small margin and uses economies of scale to be profitable. They generally do not provide business specific coverage, but create general packages. Making sure your agent clearly understands your business and has a package that adequately covers your risks is important. When you contact your insurance agent, to ask if your ranch package includes coverage of the diversification of your ranch business, be ready to succinctly describe what is involved and show that you have thought about the risks and how to manage to minimize them. Most insurance agents are not familiar with the coverage requirements of selling meat and their underwriting companies may have even less. Without a description of the business and risk management, they may not see the value of attempting to define the risk, and in some cases have either quoted a very high price or stated that they do not provide a policy in that area. Explain what will occur with processing of the animal, aging, transportation, storage, and marketing of the meat. Many agents will use this to define the risk that is being incurred. As one insurance agent stated, "the thickness of the document tends to increase underwriter security".

Things to Consider Covering in Your Business Description

1. How many years have you raised cattle?
2. How many years have you been marketing meat?

3. How many pounds of meat do you market annually?
    a. Estimated value (two previous years and this year)
4. Do you have Agri-tourism on the farm or ranch as part of the marketing?
5. Describe your marketing process?
    a. Who do you market your product to or through?
        i. If it is through a cooperative, describe their insurance coverage
    b. Describe your ownership through the process
    c. Is the meat sold as a fresh or frozen product?
6. Who processes your animals?
    a. What is the processing plant and meat inspection process?
    b. What are the quality control procedure?
        i. USDA inspected plants - Hazard Avoidance Critical Control Program (HACCP) plan
    c. Have they had a product recall?
    d. Will they store the meat on their facilities
    e. What plant security do they have? (Alarm system, fence, etc.)
7. Are there recall safety measurements?
    a. If so, what is the process?
    b. Are there tracebacks? To plant? To animal? To package?
    c. If not, how would a recall be handled?
    d. If yes, plant # and process.
8. How is the product transported from the processing plant to the sales site?
    a. Does the store pick the meat up, does the insured deliver or does the insured hire a firm to make delivers?
9. How is the meat handled at the retail level?
10. If you are overnight mailing your beef product, how is it assured to be frozen and handled correctly by the consumer upon receipt?
11. How is your business going to be sure that contractors that handle the meat are going to maintain appropriate temperatures to the meat?
    a. At the processing plant
    b. During transport

Questions for your Insurance Agent

1. Does my farm or ranch liability policy cover my direct marketing as described?
2. Is there a limit to the amount or type of direct marketing?
3. Does the commercial business policy include product liability?
4. How much should I be insured for?
5. Is my policy a "claims made", or "occurrences" policy?
    a. How does my coverage end if I change insurers?
6. What are the policy exclusions?
    a. Are defense costs included within the Limit of Liability, or are they unlimited (outside the limit)?

In his book, The Legal Guide for Direct Farm Marketing, Neil Hamilton points out that there is need to understand the kind of agent that you are working with when they make policy interpretations. Agents can work for an insurance company as a "general agent" or as an "independent" agent meaning they sell policies for a number of different companies. "In situations where the agent is employed directly by the company, what the agent knows and what the agent tells you can be held directly accountable to the company. But in situations where agents are independent, the information you share with them such as what activities you are conducting, and what the agent tells you about coverage, may not bind the company". He points out that some states, like Arkansas, have passed laws making the companies liable, in certain circumstances, for promises of independent agents. So it is best to check with your agent to fully understand their relationship with the underwriting company. He also points out that there is a need for understanding the terms and conditions of the insurance policy. Some policies limit that the claims and the occurrences must happen during a period of coverage. If you have this policy condition he states, "the effect of this could be that if the occurrence happened one year but the actual claim against the insurance isn't made until the next year, there would only be coverage if the same policy was still in force with the same insurer. This provision requires people to stay with the same insurance company or there may be a gap in between the occurrence and the claim causing the former insurer to say there is no coverage". Another policy condition that he points out for evaluation is declining value. With this condition, "the "loss" is interpreted to include the amount the insurance company spends on the defense of the claim. Depending on the amount of coverage involved and the difficulty of the defense, one effect could be that all of the coverage is used up in the cost of the defense and you are left without insurance to cover the actual claim or liability". If you have this condition you may want to consider a higher coverage value to fully protect the ranch.

The American Grassfed Association (AGA) is providing a service to its members by working with the Brown/Raynor Corporation to offer a Commercial General Liability insurance product specifically for direct meat marketers, including Products and Completed Operations coverage. Based on favorable claims experience and business longevity, the average cost of policies has been $640 per year. For more information contact Jim Thompson at jthompson@brownraynor.com. If you find the price quote acceptable, then you need to join AGA at http://www.americangrassfed.org/Membership.htmwww.aAmerican to be eligible. Other ranchers have obtained product liability from the underwriter, American Indemnity of Galveston, Texas.

Maintaining the proper temperature of meat is an important risk management activity. It is generally called cold chain security. Temperatures above 40 °F allow the growth of E coli bacteria. Short term stored and transported fresh meat should be refrigerated at temperature of 30 to 35 ° F, while optimum temperature for long term storage is 28.6 °F.

In smaller plants chilling down of processed carcasses can be a concern if they process more animals in one day than the compressors can quickly chill. Refrigeration parameters should be defined, established and recorded so that carcasses reach a temperature of 40 °F or less within 24 hours. Frozen product should be stored and transported at 0 °F or below. Adequate air movement to quickly freeze meat by using wire baskets or spacers between the boxes should always be used.

Farmers Markets can require additional insurance and risk management requirements. Some farmers markets will require proof of a 1 or as much as 2 million dollar liability policy is held by the marketer. Many require proof of insurance or to be listed on the policy as "Additional Insured". Providing samples of a cooked product at a farmers market is a good method of product promotion, but can increase liability risks. Some farmers markets prohibit it for that reason. Some areas to be addressed to reduce risks include:

- Hand washing of each vendor that prepares or serves samples
- Equipment and utensils must be easily cleanable, in good condition, and free of cracks and crevices.
- Cooking the meat to the appropriate temperature
- Storage of the meat products between cooking and tasting.

Internet sales have the challenge of maintaining the appropriate temperature during shipment to the customer. Most have attempted to address this through additional vacuum packaging of meat, ice packs or dry ice, appropriate insulated packaging, and guaranteed delivery shipping.

Forming a corporation to merchandize the meat is another way to protect the ranch and farm assets by limiting liability to the investments in the business. This adds to the cost of operating the corporation and potential additional tax considerations. Limited Liability Corporations can provide liability protection and can also address some of the tax issues. Forming a Cooperative is another method of limiting liability that can also provide the size of operation to reduce costs and secure larger markets. Cooperatives also bring the challenge of working as a group and losing the independent operation that most agriculturist value.

Some have chose to not think about this risk to their business. The worst potential is that all of the land and personnel property are at risk if your insurance carrier states that ranch liability coverage does not include food processing or the claims exceed the coverage amount.

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Consumer Acceptance and Carcass Quality

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Introduction

In commodity production systems, beef quality is designated based on the USDA grading criteria which take into account carcass marbling, maturity and yield. Producers are rewarded economically for beef quality grade (QG) of Choice versus Select although the price difference (spread) varies seasonally. Substantial research has been conducted comparing forage- to grain-finished beef but most of this research was based on feeding forage-finished animals to equal weight or compositional endpoints in an attempt to improve QG. This method of comparison results in forage-finished cattle being older due to the lower energy density of their diets and environmental factors. Animal age is associated with increased toughness both when measured as shear force and sensory tenderness. Knowledge regarding the impact of animal performance during critical phases of production and finishing system (with equal time endpoints) on end product would have significant impact on planning capabilities and economic returns. A multi-year, multi-institution research effort within the "Pasture-Based Beef Systems for Appalachia" research project was directed to study the impact of winter stocker growth rate on subsequent animal performance during finishing, and beef quality in forage- and feedlot-finished beef. The research consortium involves over 30 scientists and the following institutions: USDA-ARS, Virginia Polytechnic Institute & State University, West Virginia University, Clemson University and the University of Georgia. The material presented has been previously submitted to the Journal of Animal Science for publication.

Methods

Over a three year period, spring-born English cross-bred steer calves (72 head each year) were randomly assigned to one of three winter-stocker growth rate treatments in early December. Animals were bunk-fed timothy hay-based diets during the stocker period with either supplemental soybean meal or soybean meal and soybean hulls to achieve protein and energy balance. A commercial mineral mix containing a trace mineral and vitamin package was fed throughout the experimental periods. Winter diets were formulated to achieve average daily gains (ADG) of 0.5(L), 1.0 (M) or 1.5 (H) lb. Upon completion of the winter stocker period, animals within winter treatment were randomly

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assigned to either pasture or feedlot/concentrate finishing treatments. Pasture cattle were finished in Union, West Virginia on naturalized pasture (bluegrass, orchardgrass, fescue, and white clover mix), hay meadow re-growth (orchardgrass and alfalfa/grass mixture) and triticale/Italian ryegrass. Dry matter basis (DMB) mean crude protein (CP) content of pasture was 18.0% and invitro dry matter disappearance (IVDMD) was 81.3%. Concentrate cattle were finished at Steeles Tavern, Virginia (76.0% shell corn, 18.0% corn silage, and 5.6% soybean meal; DMB). The finishing period began in Mid-April and concluded around the end of September. Pasture and concentrate cattle were harvested to an equal time endpoint to alleviate confounding due to animal age or environment. Cattle were approximately 18 months of age when harvested. Carcass data were collected at time of slaughter and the left 107 rib (with chine) from each carcass was purchased for later chemical and trained sensory panel evaluation. Pasture cattle were de-wormed and received fly control treatment using commercial products throughout the grazing season.

Results and Discussion

Winter Rate of Gain on Carcass Quality and Consumer Acceptability: Carcass fat thickness, loin muscle area and yield grade were not influenced by winter stocker treatment. There was a trend for kidney pelvic and heart fat (KPH) (P=0.07) to be increased by greater winter rate of gain. Dressing percent and carcass weight (CW) were influenced by winter rate of gain. Increased winter rate of gain resulted in H having increased dressing percent (versus L) and heavier carcass weight (versus L and M).

Quality grade (QG) was influenced by winter rate of gain. Increased winter rate of gain resulted in H having improved QG versus L or M. There was a winter stocker treatment by finishing treatment interaction with regards to chemically determined loin muscle (LM) total lipid content. Increased winter rate of gain led to increased lipid content in feedlot-finished LM but not in LM from pasture-finished cattle. Winter rate of gain did not influence LM or subcutaneous fat color, sensory panel scores, or Warner-Bratzler shear force.

Finish System on Carcass Quality and Consumer Acceptability: Feedlot finishing increased carcass weight, loin muscle area, fat thickness, KPH, dressing percent, yield grade and QG. Feedlot-finished carcasses had a mean grade of Choice - versus Select – for pasture finished.

The fat content of the 9th-10th-11th rib section was 42% less from forage-finished compared to feedlot-finished cattle. Based on predicted carcass composition and carcass data, feedlot-finishing produced a 174 lb heavier carcass, but excess fat would account for 84 lb of that difference.

Based on photometric measurements, forage-finished LM was darker, less red and contained less yellow pigmentation than LM from feedlot-finished cattle. Subcutaneous fat was darker and more yellow for forage-finished product, agreeing with previously reported findings for forage finished beef. However, subjective scoring during carcass data collection resulted in no detectable difference in fat color between forage- and feedlot-finished.

Beef tenderness was evaluated using the Warner-Bratzler shear force test, and by trained sensory panel. There was no difference in Warner-Bratzler shear force score between forage- and feedlot finished steak for both 14 and 28 day postmortem times. Trained sensory panel evaluation data included juiciness, initial tenderness, overall tenderness, and beef flavor intensity. Participants rated samples based on an 8-point scale: 1 = extremely dry, tough and bland, to 8 = extremely juicy, tender, and intense flavor. Feedlot-finished steaks were slightly juicier than forage-finished steaks (5.0 versus 4.8). Initial and overall tenderness did not differ, 5.3 versus 5.2, and 5.2 versus 5.1, respectively. Beef flavor intensity was greater for feedlot- compared to forage-finished steak (4.9 versus 4.4).

Off-flavor intensity was evaluated on a 9-point scale: 0 = none, 1 = extremely slight off-flavor to 8 = extremely intense off-flavor. Forage-finished steaks had greater off-flavor scores (0.9 versus 1.7) compared to feedlot-finished products.

Implications

Winter stocker growth rate did not influence beef quality or composition. Feedlot-finishing resulted in higher carcass quality grade, but Warner-Bratzler and trained sensory panel evaluation revealed no difference in tenderness. Forage- and feedlot finished beef were comparable and highly desirable.

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