Kansas State University

Stocker Cattle Management & Nutrition

Kansas State Agricultural Experiment Station and Cooperative Extension Service

Stocker Cattle Management and Nutrition

Stocker cattle are young, lightweight calves raised primarily on forage diets until they reach a desired weight, then used either as part of the replacement herd or placed in the feedlot. In order for cattle producers to raise a profitable stocker herd, management, health, and nutrition are just three of the important factors to consider. Without proper consideration, the growth potential of these calves will decrease, reducing the profitability of the operation. This publication summarizes data concerning stocker cattle that deal with the health, management, and nutritional concerns necessary for a successful stocker cattle program.

Pre-Grass or Receiving Management

How the cattle are managed the first 2 to 4 weeks after arrival is definitely the most critical for any stocker cattle or feedlot operator. An operator must have *live*, healthy cattle in order to utilize management tools to improve gains and performance while grazing. Consult a veterinarian familiar with your operation for recommendations on a processing and treatment program. Here is a basic outline and general recommendations.

After arrival, provide immediate access to good quality grass hay, but withhold water and grain or supplement for 2 to 4 hours. This will give the animals time to quiet down and prevent overdrinking. The hay will stimulate the rumen to begin functioning properly after being without feed in transit. Let the cattle rest overnight and process them early the next morning.

Working the animals in small groups will decrease the amount of stress placed on each one. Ear-tag, deworm, and vaccinate all animals with IBR, PI,, leptospirosis and blackleg. Castrate and tip the horns at arrival. Highly stressed calves may need vitamins A and B_{12} and treatment with a long-acting antibiotic.

Feeding coccidiostats, such as Deccox, are given primarily to alleviate coccidiosis and are frequently fed only the first 28 days after arrival. Improved animal performance has occurred when Deccox was fed daily throughout the growing period. A reduction in sickness as well as an increase in gain and feed intake was observed when Deccox was fed to newly purchased calves *(10)*.

Oklahoma work showed a 26-percent increase in gains when Deccox was fed for 58 days *(74)*, while in another study, cattle fed Deccox gained an average of .5 lbs/hd/day more than those not fed the coccidiostat *(6)*. In these trials, Deccox was fed either hand mixed with the mineral supplement (1.5 lbs of 6 percent Deccox premix per 50 lbs of mineral) or administered through cottonseed meal pellets at the rate of 50 mg/lb in 2 lbs of supplement.

Kansas trials have shown either a slight improvement in gain (3.4 percent) when Deccox was fed to cattle on wheat pasture (9) or a nonsignificant improvement (.09 lbs/hd/day) in average daily gain (ADG) and reduction of sickness on newly purchased steers and bulls grazing native grass pasture *(14)*.

The results of feeding antibiotics or coccidiostats are variable and are highly dependent on the levels of infections and stress that the cattle have been exposed to. This is illustrated in the results of a study in Oklahoma (5) that compared feeding Deccox to 120 head purchased from auction barns and grazed on native grass to 80 head purchased from one ranch and grazed on Bermudagrass pasture. The auction-barn purchased cattle gained 20 percent more when fed Deccox, while the cattle purchased from one ranch did not differ in gains when fed Deccox. The differences in the type of pastures should not have affected the results.

Increased gains have also occurred when Deccox was fed to newly weaned calves *(95)*. Newly purchased calves that are stressed by transit, commingling, etc., should be fed Deccox to control coccidiosis and subclinical coccidiosis. Deccox should be fed at approximately 100 mg/hd/day or 23 mg/100 lbs bodyweight/day.

In summary, for cattle bought at auctions or that have undergone moderate stress, feeding some type of antibiotic or coccidiostat is recommended, particularly the first 28 days. Benefits can be obtained by feeding the cattle the entire length of the stocker program.

Implanting

Implanting stocker cattle is a must for increasing performance and profit. Recent trials show that ADG increases when implants are used *(13, 19, 20, 21, 35, 58, 61, 62, 66, 67, 69, 70, 92, 97)*. Average increases were 1.45 and 1.65 lbs/hd/day for nonimplanted vs. implanted animals using Compudose, Ralgro and Synovex implants.

Producers wonder how implants affect lifetime performance. Implants have increased ADG during the suckling and finishing phases of

Note: Numbers in parenthesis refer to references, beginning on page 14.

cattle production, although responses in the suckling phase can be somewhat variable. Laudert et al. *(60)* found that implanting suckling calves did not reduce gains during the growing or finishing phases, but implanting during the growing phase reduced finishing ADG, possibly due to compensatory gain in the finishing phase by the nonimplanted calves.

Research conducted since then, however, has shown no effect, or in some cases, a positive effect on ADG by previous implant treatment. Kansas trials found either no overall effect of previous implant treatment on ADG *(71)* or that animals implanted during the stocker phase continued to gain faster in the finishing phase *(20, 21, 35)*.

Implanting suckling calves (l–2 months of age) may depress gains in the growing and finishing phases *(77)* while other researchers have found no effect of implanting in the suckling phase on subsequent performance *(98)*. In both studies, finishing gain was not influenced by implanting during the growing phase. Lifetime ADG was increased by implanting and re-implanting throughout the various phases of production.

Implants approved for grazing cattle are Synovex S, STEER-oid, Ralgro, Compudose and Compudose-200 for steers. For heifers the approved implants are Synovex H, Heifer-oid and Ralgro.

Deworming

Calves are more susceptible to worms than yearling and older cattle. Therefore, all calves should be dewormed. Yearling and feeder cattle may not respond to anthelmintics because of previous deworming.

The necessity of deworming cattle has been questioned in terms of dollar return through improved animal performance over the cost of deworming. The use of the anthelmintics morantel tartrate, levamisole or thiabendazole decreased fecal nematode egg counts but did not affect animal performance *(30, 62, 113, 116)*. Treating with ivermectin has shown a 30 percent increase in ADG and a reduction in the sick days per head and morbidity *(50)*.

In summary: (1) deworming will reduce the number of roundworms present; (2) animal performance will be improved if the infection level was severe and (3) moderate to light levels of roundworm infestation show variable responses to treatment in animal performance *(111)*.

Management of Flies and Lice

Production losses caused by flies and lice depend on interaction with other factors such as internal parasites, plane of nutrition, temperature stress (hot or cold), and cattle genetics. When purchasing cattle, previous insecticide treatment can be useful in determining the necessity or choice of insecticide to use. Treating cattle will often depress performance for a short period and re-treating the cattle will double this depression.

Horn flies are usually the pest of most concern. Control commonly yields an extra 15 to 30 pounds of beef per stocker animal. The most effective method of control to date is insecticide-impregnated ear tags. However, pyrethroid-resistant horn fly problems have been documented in all major cattle-producing states. When using ear tags, do not apply tags until fly season begins, approximately June 1.

Stable flies are not thought to be a pest of range cattle; however in one out of three years in Kansas there are serious range populations for a period of 3 to 5 weeks. It is estimated stable flies cause more than $20 million annual loss in Kansas rangeland operations *(83)*. Face flies cause concern primarily through their transmission of pinkeye. Lice should be treated when present, but this is not a necessary part of a routine treatment program.

When grazing cattle under an intensive-early stocking system (IES), insecticide treatment may not appear to be as beneficial compared to full season grazing. With IES, the impact of the flies on the cattle during the first part of the summer will not be measurable until the end of the summer. When grazing the full season, the effects of flies are magnified. This is because the fly populations generally get worse at the end of summer, further stressing the animals when the negative results from the first part of the summer are becoming evident. Controlling flies will improve profits when using IES and is considered essential if full season grazing.

Application strategies. With increasing environmental concerns about insecticide residues, the availability of broad spectrum insecticides for cattle is decreasing. Cattlemen need to familiarize themselves with chemicals and their specific uses. Several types may be needed for effective insect control. Resistance problems can occur with any insect species to any given insecticide. Alternation of totally different chemicals is the key to preventing resistance.

Many options are available for insect control such as insecticidal ear tags, sprays, pour-ons, dust bags, backrubbers or self-oilers, and oral (feed through) larvicides or some combination of these. Good sanitation can be the best way to eliminate fly breeding sites. Successful control can be seen through improved average daily gain and feed efficiencies.

How does the nutritional status or pre-management of the incoming stocker affect performance?

This is a common but unanswered question for stocker operators. A common practice is to keep the cattle on a low plane of nutrition (particularly over the winter) by feeding low quality forage with minimal supplement. Can the gain lost during this time be made up during the stocker and finishing phases?

The results from two recent trials on the effect of wintering gain on subsequent pasture and feedlot performance showed compensatory gains during the grazing phase in animals which had gained less over the winter *(65, 114)*. This occurred to a much lesser degree in the study by White et al. *(114)*, which looked at winter gains of -.51, -.15, .35 and 1.57 lbs/hd/day, and was probably due in part to the overall low grazing and finishing performance and also possibly to the negative winter weight status of the animals.

In this case, the winter weight differences were minimized but maintained at the end of the grazing phase. This only affected the length of finishing in the feedlot, since no compensatory gains occurred during the finishing phase.

In the study by Lewis et al. *(65)*, which looked at gains of .62, .84 and 1.09 lbs/hd/day, most of the lost winter gains were regained during the grazing period. In this instance, the optimal level of the winter gain for stocker performance becomes more an economical decision, primarily relating to the cost of additional gain and time the cattle will be sold. The cattle that gained 1.09 lbs/hd/day during winter gained the most during the finishing phase, but this was due to increased intake rather than compensatory gains in respect to the pasture phase. Increased intake to improve gains is of less economic value compared to compensatory gains.

In both studies, the animals that were heaviest after wintering remained heaviest after grazing and finishing, however the weight margins varied. Managing animals' gains with respect to the next production phase may be an important consideration in overall economics. Cattle type, particularly frame size, will affect how an animal will compensate; thereby feeding management may differ and is discussed further later.

Seasonal Variation in Cattle Performance

Grasses decrease in quality with increased maturity and seasonal progression through aging and weathering. By the middle of the summer-grazing season, cool season grasses are in a dormant stage and decline tremendously in quality. There is still a fair amount of forage available, but the nutritional quality of the mature cool season grasses is lower. Warm season grasses are the predominant summer forage and produce 65-75 percent of their yield during mid-summer *(44)*. As grasses mature, leaf production decreases and stem tissue increases, decreasing forage digestibility and lowering the nutrient content of the plant. Table 1 shows the decline in crude protein (CP) and digestibility over the grazing season. Tables 1 and 2 show how this decline in quality affects animal gains.

Animals have the ability to be selective when they graze. Cattle will selectively graze forage that is lower in fiber and higher in protein. Even on improved pastures containing only one species of grass, beef cows are capable of selecting forage that is higher in quality than samples obtained by handclipping *(6)*.

Grass Management

The nutrient content of grass changes from species to species and from season to season. Cattle grazing warm season grasses have different supplemental mineral, protein and energy needs than cattle grazing cool season grasses. The two most commonly used grazing systems are continuous (season-long) and intensive-early stocked (IES).

The native grass IES system involves at least doubling the number of cattle grazed per acre of rangeland, but for a shorter grazing season. In Kansas, this is typically May 1 to July 15, when forage growth rates are highest and provide the most nutrition. In a traditional five-month continuous-grazing system, 60 to 70 percent of the total animal gains are achieved during this time. In an IES system, animals are removed at mid-season and moved to other grazing or the

TABLE 1. Monthly Steer Gains and Nutritive Values of Clipped Kansas Bluestem Pasture Forage—15-Year Average

	May	June	July	Aug.	Sept.
Avg. daily gain, lbs	2.28	1.93	1.64	1.23	1.29
Crude protein, %[a]	17.7	11.6	6.0	4.5	4.3
Crude fiber, %[a]	25.9	33.5	32.8	30.8	34.0

[a]Dry matter basis. Smith (100).

TABLE 2. Daily Gain of Steers Under Continuous Grazing of Nebraska Mixed Prairie Forage—9-Year Average

	May 15 June 15	June 15 July 15	July 15 Aug. 15	Aug. 15 Sept. 15	Sept. 15 Oct. 15
Gain, lbs.	2.14	2.04	1.76	1.40	.40

Reece *(89)*.

feedyard. This allows the vegetation time to recover, and research shows IES does not damage the plant composition in the Manhattan area.

However, at the Fort Hays Experiment Station, stocking rate greater than 2× will damage the vegetation and greater than 2.5× will reduce animal gains. Retained ownership of the cattle should be considered with this type of program. Total gain on pasture is normally reduced per head (by 30-40 percent) because of the shorter grazing period, however the greater numbers of animals per acre result in substantial increases in gain per acre.

The gain per animal during early season grazing is usually equal whether using the IES or continuous system. Grazing distribution is improved and soil moisture conserved. Other IES advantages include the ability to market the cattle mid-season, in contrast to the majority of cattle being marketed at the end of continuous grazing. Also major variable production costs, especially interest on investment in stocker cattle, are reduced about 50 percent per head by only having the cattle half of the grazing season.

Steer average daily gains (ADG) and pounds of production per acre for 1981-1988 at the Fort Hays Experiment Station are shown in Table 3. Similar data from research conducted in the Manhattan area are shown in Table 4. Both areas were stocked from May 2 to July 15. The Fort Hays stocking rates were 3.5 (season-long), 1.8 (2×), 1.4 (2.5×) and 1.15 (3×) acres per head. For the Manhattan data, stocking rates were 1.75 (2×), 1.50 (2.5×) and 1.25 (3×) acres per steer.

Burning

Intensive-early stocked pasture should always be burned because of the advantage in cattle ADG of approximately .35 lb/hd/day.

As described by Ohlenbusch and Hodges *(85)*, prescribed burning "can be used as a major management tool for native grasslands, especially in the tallgrass areas. It can control many woody plants and herbaceous weeds, improve poor grazing distribution, reduce wildfire hazards, improve wildlife habitat, and increase livestock production in stocker operations. To gain these

TABLE 3. Intensive-Early Stocking (IES) at the Fort Hays Experiment Station Effect on Steer ADG and Livestock Production

	ADG (lbs/hd/day)				Livestock Production (lbs/acre)			
Year	**SLS**[a]	**2 x**	**2.5 x**	**3 x**	**SLS**	**2 x**	**2.5 x**	**3 x**
1981	1.3	1.9	—	1.7	57	79	—	110
1982	1.3	1.8	—	1.5	57	75	—	99
1983	1.2	1.5	—	1.3	52	61	—	82
1984	1.4	1.5	1.7	1.4	60	64	93	89
1985	1.0	1.3	1.3	1.1	43	54	71	68
1986	1.4	0.9	0.9	0.6	58	38	49	37
1987	1.1	1.4	1.4	1.1	49	62	74	72
1988	1.2	1.2	1.2	0.9	46	40	53	48
Average	**1.2**	**1.4**	**1.3**	**1.2**	**53**	**60**	**68**	**76**

[a]SLS = Season-long stocking. Olson *(86).*

TABLE 4. Intensive-Early Stocking (IES) from May 1 to July 15 on Kansas Flint Hills Bluestem Pasture Effect on Steer Gains

	Gains (lb/steer)			Gains (lbs/acre)		
Year	**2 x**	**2.5 x**	**3 x**	**2 x**	**2.5 x**	**3 x**
1982	139	128	137	79	85	110
1983	133	122	137	76	81	110
1984	166	166	168	119	123	134
1985	208	184	175	119	123	156
1986	185	190	195	106	127	156
1987	178	182	187	101	121	145
Average	**168**	**162**	**166**	**96**	**108**	**133**

Owensby et al. *(87).*

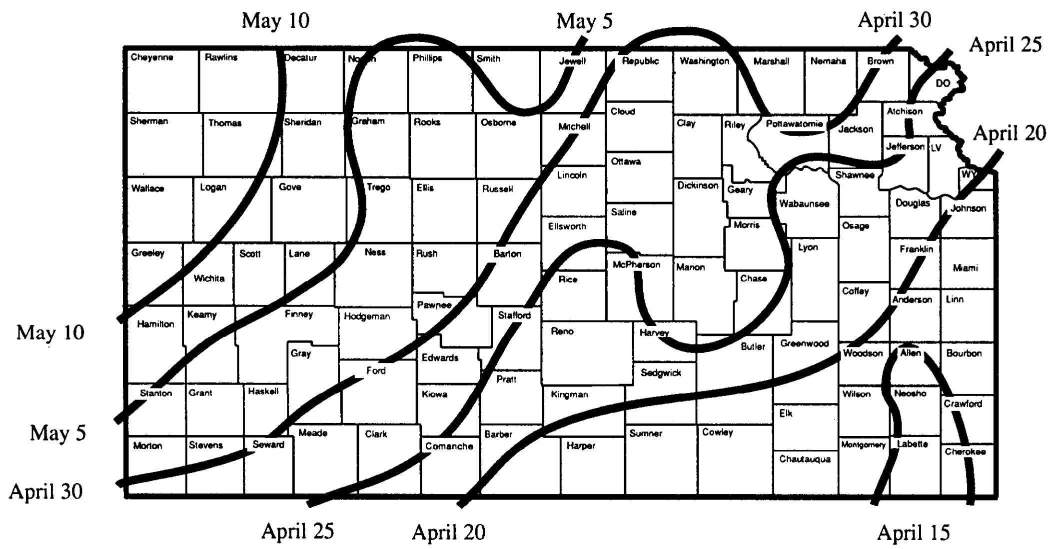

Figure 1. Average burn data in Kansas.

benefits, fire must be used under specified conditions and with proper timing. Not following appropriate precautions can lead to very tragic results. Average recommended dates of burning (based on tallgrass increase) are shown in Figure 1. It should be noted that these dates may be as much as 10 days earlier or later depending on growing conditions."

Burning in western Kansas is limited to controlling brush and weeds and improving grazing distribution. Grazing distribution can be improved by burning areas that are not usually grazed or are undergrazed. Animals are attracted to the burned areas, since the grasses are more accessible and palatable. The overgrazed areas generally will not have enough fuel to carry a fire, and will be used less and can recover.

The proper burning date is critical in regard to the effect on vegetation and cattle performance. Burning to favor desired plants should occur when they are just starting to green up and have 1 to 1½ inches of new growth. The soil profile should be filled with water and the surface should be wet *(85).*

Prescribed burning increases summer gains of growing cattle 9-12 percent or more, with most of the gain occurring in the first half of the summer *(7),* as illustrated in Table 5 with data collected at Manhattan, Kansas. Steer gains on burned and nonburned bluestem pasture over a five-year period (1978-1982) were 21 percent greater each year when cattle grazed burned pasture compared to nonburned pastures *(101).* Increased performance was a result of the animals consuming a larger quantity of more digestible forage *(95).*

Intensive-early stocking and burning. As shown in Table 1, the highest animal gains occur early in the grazing season on burned (as well as nonburned) pastures, which lends itself to possible intensive-early stocking management. An economic analysis of intensive-early or season-long stocking using burned versus unburned pastures found that intensive-early stocking returns exceeded season-long stocking *(7).*

Prescribed burning improved the receipts for both programs, but the increase was proportionally greater for intensive-early stocking in terms of average daily gain. The mean estimated returns for nonburned pastures with season-long stocking or intensive-early stocking, were 5.14 and 6.61 $/acre, respectively. For burned pastures with season-long stocking or intensive early stocking, the returns were 6.25 and 13.36 $/acre, respectively.

TABLE 5. Effect of Burning on Average Monthly Steer Gains (lb/hd/day; 16-year Summary, 1950-1965)

	May	June	July	Aug.	Sept.	Avg.
Unburned	1.83	1.74	1.59	1.24	1.44	1.53a
Early-spring burned	2.42	1.90	1.56	1.13	1.23	1.57^{ab}
Mid-spring burned	2.50	2.31	1.64	1.28	1.19	1.64^{bc}
Late-spring burned	2.36	2.06	1.75	1.28	1.28	1.70^{c}

^{abc}Two means not bearing a common superscript differ significantly ($P < .05$).
Smith *(89).*

Ionophores

Feeding ionophores is a highly recommended practice in stocker cattle production.

Rumensin improves daily gain in grazing cattle, allowing more energy to be produced per unit of feed. Average daily gain increased .11 lbs/hd/day for animals fed 1 lb or more of Rumensin supplement per head daily *(100).* When Rumensin was fed to cattle grazing low quality forage, gains were increased an average of .12 lbs/hd/day. The majority of the trials fed Rumensin at 200 mg/hd/day, with a few using 100 or 150 mg/hd/day. Brazle (unpublished) showed improved gain when Rumensin was consumed at 115 mg/hd/day or more, but this increase in gain was cut in half when Rumensin intake was only 75-90 mg/hd/day. Stocker cattle which were self-fed Rumensin supplements gained similarly to hand-fed cattle when consuming .5 lbs or less of supplement and grazing good quality forage.

In self-fed supplements, Rumensin tends to decrease intake. In general, feeding Rumensin to stocker cattle will improve weight gains, primarily through improving feed efficiency. A summary of some of the last decade of research on feeding Rumensin to stocker cattle appears in Table 6.

Bovatec produces similar results to Rumensin when included in hand-fed supplements *(Table 6),* increasing daily gain by an average of .17 lbs/hd/day. Bovatec is more palatable than Rumensin, therefore it is the ionophore of choice when limiting intake in a self-feeding system because higher levels can be incorporated. However, Rumensin will reduce the requirement for salt by 30-40 percent when self-feeding large amounts of grain, therefore it would be the ionophore of choice when a high percentage of salt is used to limit grain intake. In summary, feeding ionophores is a highly recommended practice in stocker cattle production.

TABLE 6. Effects of Feeding Ionophores On Stocker Cattle Gains

Number of trials	Method	Intake, mg/hd/day	Weight Gain, lb/hd/day -ionophore	Weight Gain, lb/hd/day +ionophore
Rumensin				
47 trials	hand-fed	144	1.52	1.62
12 trials	self-fed	88	1.37	1.52
Bovatec				
9 trials	hand-fed	193	1.64	1.81
3 trials	self-fed	162	.78	.80

Rumensin studies *(72, 75, 93, 106, 115)*
Bovatec studies *(7, 29, 34, 42, 43. 53, 73, 103)*

Salt and Mineral Supplementation

Improvements in performance may or may not occur by providing a mineral supplement, however it is cheap insurance and well worth the cost. Next to sodium (Na) and chloride (Cl), phosphorous (P) is the most important mineral for grazing cattle since forages in general are low in phosphorous. Native range contains approximately .l to .2 percent P and .3 to .5 percent Ca when growing but only about .05 percent P and .25 to .30 percent Ca when dormant.

These levels of calcium (Ca) are adequate, but are quite low for P in the dormant stage and marginal in summer. Therefore a mineral supplement fed free-choice should contain 5-8 percent P. Protein and grain supplements help provide phosphorous and some of the trace minerals. Research shows copper and zinc as two trace minerals that may improve performance when included in a supplement.

Mineral levels in forages vary depending on species, fertilization, weather conditions, and region. In the past, Kansas research has not shown benefits from supplying supplemental phosphorous, however, as stated before, mineral supplementation is cheap insurance to make sure the animal's mineral requirements are met. When supplementing cool season grasses, particularly ones that may cause grass tetany such as wheat, rye, fescue or brome grasses, the mineral mix should contain 6-10 percent magnesium. Ionophores increase the absorption of magnesium, phosphorous and sodium and may also help prevent tetany problems.

Antibiotics

Antibiotics tend to improve performance by reducing subclinical infections and also help to reduce the incidence of footrot, pinkeye and anaplasmosis. Variable results have been found when antibiotics are fed to grazing stocker cattle. Feeding either chlortetracycline (Aureomycin) or oxytetracycline (Terramycin) showed either a 21.3 percent increase in average daily gains *(16, 33, 80)* or small (< 5%), nonsignificant increases *(13, 112).* When chlortetracycline was fed to cow/calf pairs, cow and calf weight gains were increased by an average of 34 percent and 7 percent, respectively.

When oxytetracycline or chlortetracycline feeding was compared to Bovatec and/or Rumensin, oxytetracycline or chlortetracycline supplementation produced gains equal to supplementing with Bovatec or Rumensin in two trials *(13),* while in a third trial, gains were lower with chloratetracycline supplementation compared to Rumensin (1.13 vs 1.28 lbs/hd/day, respectively) *(43).* The tetracyclines can be effectively fed with mineral mixtures in open boxes when animal intake is low. Expected mineral mixture intakes for 400-600 lb animals is .10- .20 lbs/hd/day to provide 300-500 mg daily of antibiotic.

When are protein and energy supplements needed?

Supplementation can dramatically affect performance during all seasons of grazing. Balancing dietary protein and energy in supplements is important to ensure successful response to supplementation. Generally, the nutrient that is most limiting or deficient should be supplied first. The key is to have a good idea of the quality of the forage being grazed and to adjust the supplement used accordingly.

All supplements are a source of energy and protein, however those feedstuffs that are higher in their concentration of crude protein (CP) are classified as protein supplements (i.e., soybean meal, cottonseed meal, corn gluten meal, etc.) and those with lower CP concentrations relative to energy would be classified as energy supplements (i.e., corn, sorghum, wheat).

The ultimate goal of supplementation is to optimize performance or gains, but the value of the gains must be examined from an economic standpoint. The economics of supplementation should be scrutinized within each individual operation as discussed by Brethour *(11)*.

The value of added gain needs to be weighed against how that extra weight affects market price and the costs associated with the labor, equipment, etc., it took to feed the supplement, above the cost of the supplement itself. Because many factors can affect the responses, each producer's supplementation program should be tailored to the individual enterprise. The benefits of supplementation can be numerous:

1. Implants will increase gains more in cattle that are supplemented compared to those that are not.
2. More uniform gains are often achieved with supplementation.
3. Feeding a supplement provides the carrier to feed an ionophore.
4. Supplemented cattle often perform better in the feedlot, probably because they are already partially adapted to grain and an ionophore.
5. Hand-feeding tends to quiet the cattle and make them more manageable, particularly at sale time, causing less weight loss.
6. Supplementation forces a closer observation of the cattle, which can be very valuable.

Early summer grazing. Supplementing animals during the early portion of the grazing season, when pastures peak in quality, has not been researched extensively. This is probably because forage quality is adequate and supplementation is not thought to be needed, compared to other times of the year. Animals will, however, respond to energy and protein supplementation during the early summer (May through mid-July).

Up to 4 lbs of grain sorghum/hd/day can be supplemented with minimal effects on forage utilization *(107)*. Whether corn, wheat or grain sorghum is used does not appear to affect these results *(108)*. When intensive-early stocked steers grazing native tallgrass prairie were supplemented with either 0, 2 or 4 lbs/hd/day of grain sorghum, respective gains were 2.5, 2.7 and 2.9 lb/day *(28)*. At Fort Hays (1981-1985), feeding 4 lbs of grain sorghum (with 200 mg Rumensin)/hd/day to steers grazing shortgrass prairie increased daily gains by .56 lbs/hd/day with an efficiency of 7 lbs supplement/lb of gain. At Manhattan (1981-1984), feeding 1.4 lbs grain sorghum (with 156 mg Rumensin)/hd/day to steers grazing tallgrass prairie increased daily gains by .35 lbs/hd/day with an efficiency of 4 lbs supplement/lb gain.

Feeding energy-based supplements when protein is the more limiting nutrient can lead to an imbalance of protein levels and a less efficient use of the total diet. A recent Oklahoma trial compared feeding calves 1 lb/day of a 38 percent CP supplement or 3 lb/day of a 15.5 percent CP supplement for the first 28 days, increasing to 3 lbs/day of a 25 percent CP supplement for the final 28 days, to calves receiving no supplement *(82)*.

Both supplemented groups gained more (1.60 lbs/hd/day) than the unsupplemented groups (1.23 lbs/hd/day); however, the efficiency of supplement conversion was quite different, being 2.3 lbs supplement/lb of gain for the 38 percent CP supplement versus 9.2 lbs supplement/lb gain for the higher energy supplement. These results suggest that in the tallgrass prairie region supplemental protein may even be useful during the early summer.

In all of the trials reviewed, an ionophore was included in the supplements. The importance of this as well as its effect on gains should be realized. In addition, while increasing amounts of supplement will increase gains, frequently efficiency of gain will decrease. The optimal level of supplementation will ensure an optimal cost to benefit ratio. **Supplementation should *enhance* forage utilization, and often when the amount of supplement is too high, it starts replacing or can often depress forage utilization.**

Late summer through winter grazing. Forage quality decreases substantially after mid-July, particularly in protein content. Intake and digestibility will also decrease as quality decreases. If protein is limiting, it restricts the ability of the rumen microbes to break down the diet, causing poor diet utilization.

Growing cattle, and particularly young, lightweight cattle will often need more protein throughout the grazing period than the native range can provide. Animal gains must be adequate to economically justify grazing this part of the season, particularly for stocker operators.

TABLE 7. Effect of Soybean Meal Supplementation on Prairie Hay Intake[a] and Digestibility

Item	Soybean meal per day, lb				
	0	.3	.6	.9	1.5
Hay intake, lbs	10.4	11.2	13.1	13.6	15.0
Hay intake, % of BW[b]	1.88	2.03	2.36	2.44	2.68
Total intake, lbs (hay + supplement)	11.3	12.4	14.6	15.3	17.3
Dry matter digestibility. %	38.7	41.4	46.9	47.3	50.0

Guthrie et al. (46).
[a]Dry matter basis.
[b]BW = body weight.

TABLE 8. Effect of Protein or Energy Supplements on Forage Utilization

Item	no supplement	.8 lbs/day 34% CP	1.47 lbs/day 39% CP	3.1 lbs/day 12% CP
Hay intake, lbs.	9.1	13.1	15.2	12.4
Dry matter digestibility, %	49.6	54.3	58.4	56.0
Avg. daily gain, lbs.	1.44	1.88	1.97	1.78
Lbs supplement/ lb added gain	—	1.8	2.8	8.8
cost of added gain, ¢	—	20.8	36.0	60.0

Adapted from Lusby et al. (76) and Guthrie et al. (47).
The protein supplements were based on soybean meal and the energy supplement on corn.

This may justify supplementation under some conditions.

An increase in hay intake and diet digestibility was found with increasing soybean meal supplementation to cattle grazing medium quality prairie hay (harvested in July) *(Table 7).*

Kansas State University examined the effect of feeding 3.5 lb/hd/day of three different soybean meal (SBM)/grain sorghum protein supplements (13 percent, 26 percent and 39 percent CP) to 700-lb steers grazing dormant tallgrass range. The 26 percent protein supplement increased forage intake 51 percent and 32 percent greater than the 13 percent and 39 percent protein supplement, respectively *(36).*

Oklahoma research compared feeding .8 or 1.5 lbs/hd/day of a protein supplement or supplying the same total amount of protein as the .8 lb supplement in 3.0 lbs of a corn based supplement *(Table 8).* All supplements increased forage intake, digestibility and average daily gain. More response was achieved from the "protein" supplements compared to the "energy" supplement, with the "energy" supplement converted much less efficiently to gain, costing 2-3 times as much as the "protein" supplements per lb of added gain.

Many types of protein supplements can be used effectively. Corn gluten feed (CGF) has been examined as a possible protein supplement for cattle grazing dormant native range grass *(38, 79, 99).* Corn gluten feed was found to have no negative effect on forage digestion or intake and effectively increased weight gain in growing cattle consuming dormant native range grass.

Kansas State University has examined the use of wheat middlings as a protein supplement for steers consuming dormant bluestem-range forage *(104, 105).* Results showed increased forage intake and dietary dry matter digestibility with 3.5 lb/hd/day wheat middling supplementation. It was also found that for wheat middlings-based supplements, crude protein concentrations need to be 20 percent or higher to optimize usage of poor quality forage.

When alfalfa hay and dehydrated alfalfa pellets were fed to provide the same amount of protein as a 25 percent CP SBM/ grain sorghum supplement (.6 lb protein/hd/day), forage intake and digestibility were increased, compared to unsupplemented steers *(37).*

Current Kansas State University recommendations for supplementing cattle grazing poor quality range forage: Supplements need to be 20 percent CP or higher when using grain-based supplements (i.e., soybean meal/grain sorghum). When supplementing with fiber-based protein supplements (dehydrated alfalfa, CGF, wheat middlings), the percent crude protein is not as important as the amount (lbs) of crude protein supplied.

Unlike protein supplements, feeding energy supplements (ground corn) to cows consuming poor quality hay decreases forage intake and digestibility, especially when fed at high levels (> 4 lbs/hd/day) *(27).*

High fiber by-product feeds such as corn gluten feed (CGF) and soybean hulls have shown promising results as energy supplements in that they do not decrease forage intake as much as high starch energy feedstuffs. While CGF has been mainly examined as a protein supplement, when fed to heifers on late summer native range, heifers supplemented with SBM/CGF or CGF gained more weight than SBM supplemented heifers (1.7, 1.6 vs 1.4 lb/day, respectively) *(39).* Cows fed 6.2 lb/hd/day of a corn/cottonseed meal mixture or 7.8 lb/hd/day of soybean hulls lost less weight and body conditioning (–132 lbs., –.6 units change; –101 lbs, –.3 units change) than cows fed 3.3 lb/head/day of cottonseed meal (–154 lbs, –1.1 units change) *(49)*. Low quality hay intake in cows supplemented with either 0, 2.2, 4.4 or 6.6 lbs of soybean hulls was maximized with 2.2 lbs of soybean hulls *(78)*. Soybean hulls provides an alternative to cereal grains as a high energy supplement to cattle consuming low quality forage.

Feeding urea (or nonprotein nitrogen) does not usually achieve nearly the same gains that natural protein supplements do. Cows grazing low quality native range lost more weight when supplemented with extruded urea-grain or 15 percent CP SBM supplement, compared to cows receiving a 30 percent CP SBM supplement *(64)*. Lactating cows grazing native range forage lost more weight and consumed less forage when supplemented with urea than cows receiving a natural protein supplement *(40)*.

Steers fed a natural protein source (cottonseed meal) gained 3.4 lb/hd more than steers supplemented with corn/urea *(81)*. While urea is a cheap source of protein, and using it in a self-feeding program (such as mixed with molasses in lick tanks can be a less expensive route), one must realize that animal gains will be reduced, compared to animals receiving natural protein sources.

It is important that if you supplement with an energy-based supplement during the winter, you can depress forage intake and digestibility. Feeding approximately 2 lbs/hd/day of a high protein (> 35 percent CP) supplement to cattle grazing native range should support .3 to .5 lbs gain/hd/day. Dormant native range grasses are low in protein (2-5 percent CP) and therefore protein is generally the first limiting nutrient. While protein supplements can be fed three times per week, energy supplements usually depress grazing performance if consumed in large amounts at one time and should be fed daily.

Will supplementing on pasture affect feedlot gains?

The effect of feeding 4 lbs of ground corn to steers grazing irrigated pastures of orchardgrass, smooth bromegrass and alfalfa mixtures *(Table 9)* decreased the time required to finish steers in the feedlot *(56)*. Feeding 4 lbs grain sorghum with 200 mg Rumensin/hd/day to steers grazing summer grass increased gain on pasture. Pasture, feedlot and total lbs gain/steer were 117 vs 156, 396 vs 413, and 513 vs 569, respectively, for nonsupplemented versus supplemented animals. Feed conversion of the supplement on pasture was 7.4 lbs/lb added gain. The supplemented steers retained the added weight gained during grazing and even gained slightly faster in the feedlot *(23)*.

Are supplements needed when grazing winter wheat?

Winter wheat pasture generally contains 20-30 percent CP, which is more than adequate for cattle. However, feeding 1.75 lbs/hd/day of protein supplements that are not digested very well in the rumen and by-pass partially to the small intestine (e.g. meat meal, feather meal, blood meal, brewers grain, etc.) have increased daily gains by approximately .25 lbs/hd/day or 11.8 percent over animals not receiving supplement *(4, 55, 110)*. Feeding cottonseed meal, which is intermediate in ruminal protein digestibility, showed similar improvements in gain *(55, 110)*. The increased gains achieved when supplementing protein to cattle grazing wheat pasture is due to increased forage intake *(2, 3, 109)*. When moderate to high levels (1 to 1.5 percent of body weight) of grain were supplemented to cattle grazing small grain pastures, gains ranged from .11 to .65 lbs/day with a supplement conversion of 6.7 to 10.3 lb of supplement/lb of increased gain per acre *(51)*.

Supplementation with either a corn-based energy supplement or a high-fiber energy supplement allowed stocking density to increase from 2 to 1.5 acre/steer. Daily gain was increased by supplementation (2.14 lb/hd/day vs 2.26 lb/hd/day for unsupplemented vs supple-

TABLE 9. Effect of Pasture Supplementation (Ground Corn) on Pasture Gain and Feedlot Performance

Pasture Supplement lb/day	119 d Pasture Gain, lb/d	Subsequent Feedlot Performance				
		Initial Wt., lb	Final Wt., lb	Days on Feed	Daily Gain, lb	Feed/ Gain, lb
0	1.43	675	1,174	144	3.49	5.9
1	1.45	686	1,168	137	3.52	6.0
2	1.50	673	1,129	130	3.51	6.0
3	1.65	715	1,174	123	3.73	5.5
4	1.94	735	1,160	116	3.65	5.6
5	1.87	711	1,100	109	3.57	6.1
6	1.87	724	1,100	102	3.69	5.9

Lake et al. *(56)*

mented steers). Also fiber-based supplemented steers gained more than corn-based supplemented steers (2.19 lb/hd/day vs 2.30 lb/hd/day for corn-based vs fiber-based) *(54)*.

How can I use salt to limit supplement intake and allow self-feeding?

Rich et al. *(90)* at Oklahoma State University wrote an excellent publication on limiting feed intake with salt, the highlights of which will be presented here.

In using salt to control supplement intake, formulate the supplement using a daily voluntary intake of salt at .l lb salt/100 lbs body weight. Use coarse, plain white salt, *not* trace mineralized salt that is expensive and could cause mineral imbalances when consumed at high levels. If trace mineralized salt is included in the supplement, include it to be consumed at < .02 percent of the animal's body weight (i.e., .l lbs for a 500 lb animal).

The other supplement ingredients should be similar in particle size as the salt, so animals cannot sort out the salt. Adequate forage must be available so the cattle are not forced to eat the supplement to survive.

If the animals have never eaten concentrates before, a week may be needed to hand-feed the supplement without salt as training. Then begin feeding the salt-containing supplement at a high salt level (50:50 or 60:40 salt to meal) to prevent overeating. Then reduce the salt level to obtain the desired level of intake. The salt content may need to be adjusted as the animals become accustomed to the supplement.

If an ionophore is included in the supplement, this may or may not depress intake, therefore less salt may be needed. Research shows that intake can be depressed by feeding Rumensin. The salt content in the Rumensin-containing supplement was 40 percent lower (12 vs 19 percent) than the supplement not containing an ionophore, yet intake of the supplement was still depressed by 11.7 percent. Also, half as many adjustments in salt levels had to be made in those supplements containing Rumensin *(31, 84)*.

Most important when feeding salt-limited supplements is the availability and quality of water. The rule-of-thumb is that water consumption will increase 50–75 percent. The amount of salt in the water will affect how you use salt-limited supplements.

Salt content in water is measured by total dissolved solids (TDS), which include calcium, magnesium, salt, sulfates and bicarbonates. If TDS is high, the salt content in the supplement must be reduced. If the TDS is > 5,000, caution is advised. In that case, salt-limited supplements are probably not recommended. The supplement might be refused or the cattle forced into a toxicity situation.

Don't overlook water!

Water is the most important nutrient required by the animal in the largest amounts. It is also the most abundant and the cheapest to provide. The body can lose and yet still survive 100 percent of its fat, 50 percent of its protein, but less than 10 percent of its water. After one day of water deprivation, the animal becomes uncomfortable and goes off-feed; after two days the animal becomes sick, and by three days it will probably die.

The major factors affecting water requirements are age, performance level, environmental conditions, salt and feed intake level, and the nature of the diet. A 600-lb growing animal will consume 5-6 gallons/hd/day during winter, 7-8.5 gallons during spring and fall, and increase consumption as much as 13 gallons during the hot summer months *(41)*.

There is no question that restricting water intake leads to reduced feed intake. The body will compensate by keeping the feed in the gastrointestinal tract longer and digesting it more completely. The increased digestibility, however, will not fully compensate for the loss of performance from eating less feed. If water has been restricted for some reason and then suddenly made available, overdrinking or water toxicity can be a very real problem. *Force gradual* access to the water initially when the animals are extremely thirsty.

The mineral content of the water or water quality can also affect water and feed intake as well as animal performance. Water quality, as described in the previous section, is measured by its total dissolved solids (TDS) content. Ray *(88)* studied the effect of normal (N) levels of dissolved salts in water versus high TDS levels (described as saline water, S) on feed and water consumption and performance *(Table 10)*. Four water treatment combinations were used in two consecutive 56-day periods.

If water high in TDS is all that is available, water consumption may

TABLE 10. Effect of Water Source on Performance Traits

Water source[a]	No. of pens	ADG, lbs	Avg daily feed, lbs	Feed/gain	Water, gal/d
N–N	16	2.34[c]	15.1[c]	6.59[b]	7.74
N–S	16	2.14[b]	14.4[bc]	6.94[c]	7.82
S–N	16	2.09[b]	13.7[b]	6.75[bc]	7.87
S–S	16	2.12[b]	13.8[b]	6.86[c]	8.27
SE		.04	.15	.08	.21

Adapted from Ray (88)

[a]N = 1,300 ppm dissolved salts. S = 6.000 ppm dissolved salts. Combinations of N and S refer to water source during consecutive 56-d periods.

[bc]Means within column with different superscripts differ (P < .05).

be slightly increased, while feed consumption will decrease. Consuming excessive amounts of some minerals can lead to imbalances of other minerals, such as copper deficiency resulting from excessive levels of molybdenum or sulfur. If water is moderate in TDS content and if feed levels become high in minerals and other compounds (such as in years of drought), problems can arise that normally would not. Nitrate toxicity would be an example of this.

Water facilities can be used for proper distribution of livestock. Cattle should not have to travel long distances for water. Rather than travel long distances to better forage, cattle will graze the areas closest to water. The optimum travelling distance to water is $^3/_8$–¾ miles (maximum 1 mile) on rolling terrain and ¾ to 1 mile (maximum 1 ½ miles) on flat terrain *(96).*

How will the following factors affect gain?

How do heifer and steer gains compare? Steers normally gain .20 lbs/hd/day more than heifers on grass. In a study where heifer and steer mates were grazed on red clover and fescue pasture, the steers outgained the heifers by .15 lbs/hd/day. However, when stocker cattle are not gaining at their maximum genetic growth level, then differences in gain between classes and types of cattle narrow. In some cases there may be little difference in lbs of gain/day between steers and heifers if they are fed to gain 1-1.5 lbs/hd/day.

Age or weight. Age or weight does not accurately describe cattle type without information on frame size and breed. Previous nutrition and other factors come into play when trying to predict how just age or weight will affect stocker gains. In general, in fall-weaned calves ranging from 250-550 lbs grazing wheat pasture, the lightweight steers will gain more than the heavier steers *(52).*

In a three-year study where short yearling heifers (ranging from 295-650 lbs) grazed burned-double-stocked native grass, the lighter-weight heifers had slightly higher gains *(15).*

You might ask how gains (and profitability) would be affected if the cattle were put directly into the feedlot after weaning, versus normal backgrounding and then finishing.

A recent Nebraska study *(Table 11)* has shown calves placed directly in the feedlot for 206 days consumed less feed, gained slower but were more efficient in the finishing period, compared to calves which were grown on forage (wintered and summer grazed for a total of 280 days) and then placed into the feedlot. From an economic standpoint, the cost of gains was not much different, with grain price and wintering costs the primary factors. The cattle grown on forage had the greatest returns regardless of grain price because of the increased total weight produced.

Breed type or frame score. Recent research shows there is considerable variation in lifetime performance due to frame size or breed type. Frame size is reflective of breed type and since frame categories more accurately describe expected performance it is the terminology that will be used in this discussion. When trying to assess how frame size affects stocker gains, previous management and finishing performance must also be looked at to get the whole picture. This information is useful to the cattle producer, stocker and feedlot operators, but is probably most meaningful to producers who retain ownership through all phases.

Research at Fort Hays shows that nutritional management during the winter/spring growing and intensive-early stocking summer grazing phases is related to frame size and how the animal subsequently performs. When the level of nutrition was controlled during the growing phase (January–April) using small, medium or large framed steers, subsequent frame type response during summer grazing and feedlot performance was measured *(24, 25).* Feedlot performance of large frame cattle wintered on a low plane of nutrition (1.2 lbs/hd/day) was not affected by pasture gains as much as small frame cattle. The large frame cattle continued to show compensatory gains into the feedlot phase while the small and medium frame cattle did not.

Whether or not supplement (4.4 lbs grain sorghum/hd/day) was fed to these animals had different effects on the different frame cattle. Summer supplementation response

TABLE 11. Performance of Cattle in Two Production Systems—3 Years Data

	System	
Item	**Weaning-Finishing**	**Weaning-Pasture-Finishing**
Weight, lb		
Birth	88	88
Weaning	518	513
After stalks (59 d)		591
After winter (fed husklage for 106 d)		709
After pasture (115 d)		854
Final	1,169[a]	1,311[b]
Daily gain, lb	2.76[a]	3.75[b]
Feedlot feed/gain, lb	6.24[a]	7.29[b]

Adapted from Lewis et al. *(66).*
[a]Means within rows with different superscripts differ (P < .05).

increased when the large frame steers had been wintered to gain more, but the opposite occurred for the small and medium framed steers, who responded more to supplementation when they had been wintered to gain low or medium levels of gain. Brethour and Mullen *(25)* made the following conclusions and recommendations from this very useful research:

- Feed small framed cattle more during the growing period than is customary for traditional, full-season grazing. They will retain most of that additional gain until slaughter. This especially holds true if summer supplementation is not practiced.

- If gains of small framed cattle are kept low during the growing period and the cattle are thin when turned out on grass, they probably will respond profitably to pasture supplementation.

- If it is not feasible to provide grain supplementation on pasture, do not increase growing period gains of medium and large framed cattle above the amount needed to keep cattle in a growing and thrifty condition. Larger framed cattle have the ability to compensate when they are full fed during the finishing phase.

- If summer supplementation is feasible, larger framed cattle can be fed to gain as much as 2 pounds per day during the growing period, and most of that additional gain will be retained until slaughter.

- If cattle are sold on a carcass grade basis at the end of the finishing period, it may be important to consider pasture supplementation to increase the proportion of USDA choice carcasses, especially among larger framed cattle that have been wintered at low levels of nutrition.

These recommendations were made from the perspective of retained ownership of the cattle from birth to slaughter. It should be pointed out that while the larger frame or heavier weight cattle will generally remain the heaviest cattle after grazing or finishing in the feedlot, these cattle also require more grass or feed to maintain their weights. This means increased feed costs, which should be closely examined by the producer in his particular situation. Smaller cattle will allow heavier stocking rates and therefore possibly a different picture of pounds produced on a per-acre basis.

Breeds do not differ greatly in ability to utilize forages. However some research has suggested Brahman and Brahman cross cattle may utilize forage better than some other breeds. A Kansas study showed that Longhorn, Simmental and Brahman cross cattle gained as well or better than typical British crossbred cattle *(91)*. Even during the winter, in Kansas and as far north as Canada *(62)*, Brahman cross cattle have performed as well and generally better than the typical breeds used in those areas. A Z-trial summary of different breed types grazing native grass pastures in Kansas is shown in Table 12. There was little difference in gain between breeds. For grazing periods of 75 to 120 days, cattle gaining at their genetic abilities can result in little differences in pound of gain between breed types.

How much will gains be reduced if calves are bought as bulls and castrated upon arrival? A five-trial summary in Table 13 shows the effect on gain of purchasing bull calves and castrating them at arrival. Over a 74-day period, the calves purchased as bulls gained 22 percent less or .36 lbs less/hd/day than calves already castrated.

TABLE 12. 15-Trial Summary of Effects of Breed Type on Cattle Gains on Grass

Breed	ADG
Hereford	1.70
Angus	1.61
Angus-Hereford	1.65
Dairy cross	1.72
Exotic cross (Charolais and Sin-mental)	1.77
Brahman cross	1.79
Limousin cross	1.69

Brazle. Unpublished data.
Breed types were visually determined. 2,500 yearling cattle were used.

TABLE 13. Summary of Calves Purchased as Bulls (Then Castrated) or as Steers (5 Trial Summary)

Item	Steers	Castrated bulls
No. cattle	1,949	1,002
Starting weight	541	537
Daily gain, lb (27 d avg)	2.11	1.37
Daily gain, lb (74 d avg, pasture or silages)	1.63	1.27

Brazle et al. (11, 17, 18)

Heifer Management-should I spay or feed MGA?

Spaying. Several excellent reviews have been written on spaying heifers *(26, 45, 57, 92)*. Spaying heifers will have a minimal effect on gains. A summary of seven grazing trials using 491 heifers showed a 5.5 percent decrease in gain of nonimplanted spayed heifers compared to nonimplanted intact heifers *(26, 92)*. When implants were used gains were 2.9 percent greater for spayed versus intact heifers *(26, 4.5, 59, 92)*. Implanting is always a necessity, but the data illustrate that it is particularly important in spayed heifers.

The primary advantage of spaying is the guaranteed nonpregnant status of the heifer and marketability as such. Pregnancy in feeder heifers is costly, primarily in the feedlot and when slaughtered. Therefore cow/calf and stocker operators have to be very conscious of pregnancy problems. Pregnancy and possible abortions can also cause gain reductions for the stocker operator. The cost of spaying is approximately .68 $/cwt. for a 700 lb animal *(26)* while spayed heifers can bring a premium of l-3 $/cwt. *(57)*. Not all feedlots will pay a premium, however, depending on their management program for pregnant heifers *(57)*. Other advantages to spaying other than pregnancy prevention:

1. Increased freedom in interstate shipment—spayed heifers are treated essentially as steers.
2. Brucellosis vaccination is not needed.
3. No pregnancy exams needed at time of sale.
4. Heat suppressing agents such as MGA are not needed.
5. Reduced physical activity associated with heat.

The major factors in deciding to spay is the amount of pregnancy risk within the producers situation and securing premium prices with the feedlot.

MGA or melengestrol acetate. The efficacy of feeding MGA to grazing heifers was examined. When MGA was fed either in a grain based supplement or mixed with the mineral supplement, gain was not significantly affected but signs of estrus were suppressed *(12, 32, 68)*.

Literature Cited

1. Andersen, M.A. and G.W. Horn. 1987. J. Anim. Sci. 65:865.
2. Andersen, M.A., G.J. Vogel, G. W. Horn and K.B. Poling. 1988a. Okl. Anim. Sci. Res. Rep. MP-125.
3. Andersen, M.A., G.J. Vogel, G. W. Horn and K.B. Poling. 1988b. Okl. Anim. Sci. Res. Rep. MP-125.
4. Anderson, S.J., R.T. Brandt, Jr. and J.K. Elliott. 1987. Kansas Ag. Exp. Sta. Rep. of Prog. 518.
5. Barnes, K.C., K.S. Lusby, F. Still and D. Taylor. 1984. Okl. Anim. Sci. Res. Rep. MP-116.
6. Barnes, K.C., K.S. Lusby, F. Still and D.R. Taylor. 1985. Okl. Anim. Sci. Res. Rep. MP-117.
7. Bernardo, D.J. and F.T. McCollum. 1987. Okl. Anim. Sci. Res. Rep. MP-119.
8. Blasi, D. and J. Ward. 1990. Ph. D. Thesis. Univ. of Neb., Lincoln.
9. Brandt, Jr., R.T., J.K. Elliott and J.M. Carrica. 1987. Kansas Ag. Exp. Sta. Rep. of Prog. 518.
10. Brazle, F.K. 1986. Kansas Ag. Exp. Sta. Rep. of Prog. 494.
11. Brazle, F.K. 1987. Kansas Ag. Exp. Sta. Rep. of Prog. 514.
12. Brazle, F.K. 1987. Kansas Ag. Exp. Sta. Rep. of Prog. 517.
13. Brazle, F.K. 1988. Kansas Ag. Exp. Sta. Rep. of Prog. 539.
14. Brazle, F.K. 1990. Kansas Ag. Exp. Sta. Rep. of Prog. 592.
15. Brazle, F.K. and G. Kuhl. 1986. Kansas Ag. Exp. Sta. Rep. of Prog. 494.
16. Brazle, F., G. Kuhl, D. Harmon and S. Laudert. 1987. Kansas Ag. Exp. Sta. Rep. of Prog. 514.
17. Brazle, F.K., J. Riley, F. Blecha and J.B. McLaren. 1985. Kansas Ag. Exp. Sta. Rep. of Prog. 470.
18. Brazle, F.K. and R.R. Schalles. 1986. Kansas Ag. Exp. Sta. Rep. of Prog. 494.
19. Brazle, F. and J. Whittier. 1988. Kansas Ag. Exp. Sta. Rep. of Prog. 539.
20. Brethour, J. 1981. Kansas Ag. Exp. Sta. Rep. of Prog. 399.
21. Brethour, J. 1983. Kansas Ag. Exp. Sta. Rep. of Prog. 432.
22. Brethour, J.R. 1985. Proc. 11th Ann. O-K Beef Cattle Conf.
23. Brethour, J.R. and J.L. Launchbaugh. 1985. Kansas Ag. Exp. Sta. Rep. of Prog. 475.
24. Brethour, J.R. and R.G. Mullen. 1986. Kansas Ag. Exp. Sta. Rep. of Prog. 498.
25. Brethour, J.R. and R.G. Mullen. 1989. Kansas Ag. Exp. Sta. Rep. of Prog. 570.
26. Brownson, R. 1988. Great Plains Beef Cattle Handbook. GPE-1904.
27. Chase, C.C., Jr. and C.A. Hibberd. 1985. Okl. Anim. Sci. Res. Rep. MP-117.
28. Cochran, R.C., C.E. Owensby and E.S. Vanzant. 1989. Kansas Ag. Exp. Sta. Rep. of Prog. 567.
29. Coffey, K.P. and L. W. Lomas. 1987. Kansas Ag. Exp. Sta. Rep. of Prog. 517.
30. Coffey, K.P. and L. W. Lomas. 1988. Kansas Ag. Exp. Sta. Rep. of Prog. 543.
31. Coffey, K.P., J.L. Moyer and L.W. Lomas. 1989. Kansas Ag. Exp. Sta. Rep. of Progress 567.
32. Corah, L.R. and F.K. Brazle. 1986. Kansas Ag. Exp. Sta. Rep. of Prog. 494.
33. Corah, L., F. Brazle and J. Davidson. 1981. Kansas Ag. Exp. Sta. Rep. of Prog. 394.
34. Corah, L., J. Riley, S. O'Neill and R. Pope. 1983. Kansas Ag. Exp. Sta. Rep. of Prog. 427.
35. Corah, L.R., J.G. Riley and R. Pope. 1982. Kansas Ag. Exp. Sta. Rep. of Prog. 413.
36. Davis, Jr., G. 1982. Kansas Ag. Exp. Sta. Rep. of Prog. 416.
37. DelCurto, T., R.C. Cochran, L.R. Corah, A.A. Beharka and E.S. Vanzant. 1989a. Kansas Ag. Exp. Sta. Rep. of Prog. 567.
38. DelCurto, T., R.C. Cochran, T.G. Nagaraja, A.A. Beharka and E.S. Vanzant. 1989b. Kansas Ag. Exp. Sta. Rep. of Prog. 567.
39. Fleck, A.T., K.S. Lusby and F.T. McCollum. 1986. Okl. Anim. Sci. Res. Rep. MP-118.
40. Fleck, A.T., K.S. Lusby and F.T. McCollum. 1987. Okl. Anim. Sci. Res. Rep. MP-119.
41. Forero, O., F.N. Owens and K.S. Lusby. 1980. J. Anim. Sci. 50:532.
42. Fox, D.G. and O.E. Olson. Great Plains Beef Cow-Calf Handbook. GPE-1400.

43. Gill, D.R., E.J. Richey, F.N. Owens and K.S. Lusby. 1982. Okl. Anim. Sci. Res. Rep. MP-112.

44. Graber, R.W., E.F. Smith, C.E. Owensby, J. Riley and R.R. Schalles. 1985. Kansas Ag. Exp. Sta. Rep. of Prog. 470.

45. Griffin, J.L. and G.A. Jung. 1983. Agron. J. 75:723.

46. Grotelueschen, D. 1987. Proc. Range Beef Cow Symp X. Cheyenne, WY.

47. Guthrie, M.J., D.G. Wagner and D.S. Buchanan. 1984a. Okl. Anim. Sci. Res. Rep. MP-116.

48. Guthrie, M.J., D.G. Wagner and D.C. Weakley. 1984b. Okl. Anim. Sci. Res. Rep. MP-116.

49. Gutierrez, G.G., L.M. Schake and F.M. Byers. 1982. J. Anim. Sci. 54:863.

50. Hibberd, C.A., C.C. Chase and C. Worthington. 1986. Okl. Anim. Sci. Res. Rep. MP-118.

51. Hicks, R.B., D.R. Gill and R.L. Ball. 1986. Okl. Anim. Sci. Res. Rep. MP-118.

52. Horn, G.W. 1990. Wheatland Stocker Conference. Okl. State Univ. Coop. Ext. Service.

53. Horn, G.W., T.L. Mader, S.L. Armbruster and R.R. Frahm. 1981. J. Anim. Sci. 52:447.

54. Horn, G.W., R.W. McNew and K.B. Poling. 1984. Okl. Anim. Sci. Res. Rep. MP-116.

55. Horn, G.W., W.E. McMurphy, F.T. McCollum and M.D. Cravey. 1990. Unpublished data.

56. Horn, G. W., CA. Strasia, J. Martin and G. Vogel. 1987. Okl. Anim. Sci. Res. Rep. MP-119.

57. Lake, R.P., R.L. Hildebrand, D.C. Clanton and L.E. Jones. 1974. J. Anim. Sci. 39:827.

58. Laudert, S.B. 1986. Proc. Scott Co. Beef Cattle Conf. Scott City, KS.

59. Laudert, S., L. Corah, R. Nelson and C. Sauerwein. 1985. Kansas Ag. Exp. Sta. Rep. of Prog. 470.

60. Laudert, S.B., G.L. Kuhl and A.J. Edwards. 1987. Kansas Ag. Exp. Sta. Rep. of Prog. 514.

61. Laudert, S.B., J.K. Matsushima and M.W. Wray. 1981. Col. Beef Nutr. Res. GS-999.

62. Laudert, S. and C. Saverwein. 1986. Kansas Ag. Exp. Sta. Rep. of Prog. 494.

63. Laudert, S., C. Sauerwein and G. Harris. 1983. Kansas Ag. Exp. Sta. Rep. of Prog. 427.

64. Lawson, J.E. 1984. Breeding Beef Cattle in a Range Environment, Fort Keogh Research Symp. Miles City, MT.

65. Lemenager, R.P., F.N. Owens and R. Totusek. 1978. J. Anim. Sci. 47:255.

66. Lewis, M., T. Klopfenstein, B. Anderson. 1989. Neb. Beef Cattle Rep. MP-54.

67. Lewis, M., T. Klopfenstein, M. Nielsen, R. Stock and C. Hunt. 1989. Neb. Beef Cattle Rep. MP-54.

68. Lomas, L.W. 1982. Kansas Ag. Exp. Sta. Rep. of Prog. 413.

69. Lomas, L. W. 1983. Kansas Ag. Exp. Sta. Rep. of Prog. 433.

70. Lomas, L.W. 1984. Kansas Ag. Exp. Sta. Rep. of Prog. 448.

71. Lomas, L.W. 1984. Kansas Ag. Exp. Sta. Rep. of Prog. 450.

72. Lomas, L.W. 1985. Kansas Ag. Exp. Sta. Rep. of Prog. 472.

73. Lomas, L.W. and K.P. Coffey. 1987. Kansas Ag. Exp. Sta. Rep. of Prog. 517.

74. Lomas, L. W. and J.L. Moyer. 1987. Kansas Ag. Exp. Sta. Rep. of Prog. 517.

75. Lusby, K.S., V.J. Brorsen, V.L. Stevens and R.M. Farabough. 1985. Okl. Anim. Sci. Res. Rep. MP-117.

76. Lusby, K.S., D.R. Gill and H.E. Jordan. 1984. Okl. Anim. Sci. Res. Rep. MP-116.

77. Lusby, K.S., G. W. Horn and M.J. Dvorak. 1982. Okl. Anim. Sci. Res. Rep. MP-112.

78. Mader, T.L. D.C. Clanton, J.K. Ward, D.E. Pankaskie and G.H. Deutscher. 1985. J. Anim. Sci. 61:546.

79. Martin, S.L. and C.A. Hibberd. 1987. Okl. Anim. Sci. Res. Rep. MP-119.

80. McCollum, F.T., D.R. Gill and R.L. Ball. 1985. Okl. Anim. Sci. Res. Rep. MP-117.

81. McCollum, F.T., D.R. Gill and R.L. Ball. 1988. Okl. Anim. Sci. Res. Rep. MP-125.

82. McCollum, F.T. and G. W. Horn. 1986. Okl. Anim. Sci. Res. Rep. MP-118.

83. McCollum, F.T. and K.S. Lusby. 1989. Okl. Anim. Sci. Res. Rep. MP-127.

84. Mock, D.E. 1990. Coop. Ext. Service, Kansas State Univ., Manhattan. C-671.

85. Muller, R.D., E.L. Potter, M.I. Wray, L.F. Richardson and H.P. Grueter. 1986. J. Anim. Sci. 62:593.

86. Ohlenbusch, P.D. and E.P. Hodges. 1983. Coop. Ext. Service, Kansas State Univ., Manhattan. L-663 (out of print–Replaced by L-815).

87. Olson, K.C. 1989. Kansas Ag. Exp. Sta. Rep. of Prog. 570.

88. Owensby, C.E., R.C. Cochran and E.F. Smith. 1988. Kansas Ag. Exp. Sta. Rep. of Prog. 539.

89. Ray, D.E. 1989. J. Anim. Sci. 67:357.

90. Reece, P.E. 1983. Proc. Range Beef Cow Symposium VIII. Sterling, CO.

91. Rich, T.D., S. Armbruster and D.R. Gill. Great Plains Beef Cattle Handbook. GPE-1950.

92. Riley, J. and R. Pope. 1986. Kansas Ag. Exp. Sta. Rep. of Prog. 494.

93. Rupp, G., B. Bennett, C. Kimberling and M. Shoop. 1983. Proc. Range Beef Cow Symp. VIII. Sterling, CO.

94. Rush, I.G. and B. VanPelt. 1987. Neb. Beef Cattle Rep. MP-52.

95. Rush, I.G. and B. VanPelt. 1989. Neb. Beef Cattle Rep. MP-54.

96. Schulze, L.L. and N.E. Schlesener. 1979. Proc. Kansas Ranch Mgt. Field Day. p. 11.

97. Scott, R.R., C.A. Hibberd, B.D. Trautman and C. Worthington. 1988. Okl. Anim. Sci. Res. Rep. MP-125.

98. Simms, D., A. Dinkel, D. Jepsen and R. Schalles. 1983. Kansas Ag. Exp. Sta. Rep. of Prog. 427.

99. Simms, D.D., T.B. Goehring, R.T. Brandt, Jr., G.L. Kuhl, J.J. Higgins, S.B. Laudert and R.W. Lee. 1988. J. Anim. Sci. 66:2736.

100. Simms, D., G. Kuhl and R. Schalles. 1984. Kansas Ag. Exp. Sta. Rep. of Prog. 448.

101. Smith, E.F. 1981. Kansas Ag. Exp. Sta. Bull. 638.

102. Smith, E.F. and C. Owensby. 1983. Kansas Ag. Exp. Sta. Rep. of Prog. 427.

103. Smith, S.C., K.S. Lusby, T.L. Evicks, D.R. Bailey, G.R. Jones and E.D. Allen. 1989. Okl. Anim. Sci. Res. Rep. MP-127.

104. Spears, J.W. and R.W. Harvey. 1984. J. Anim. Sci. 58:460.

105. Sunvold, G.D., R.C. Cochran and E.S. Vanzant. 1990. Kansas Ag. Exp. Sta. Rep. of Prog. 592.

106. Sunvold, G.D., R.C. Cochran, E.S. Vanzant, S.D. Brandyberry, R.B. Hightshoe and T. DelCurto. 1989. Kansas Ag. Exp. Sta. Rep. of Prog. 567.

107. Trotter, T., R. Olson, B. Brown, T. Klopfenstein, D. Brink and R. Stock. 1981. Neb. Beef Cattle Rep. EC 81-218.

108. Vanzant, E.S., A.A. Beharka, R.C. Cochran, T.B. Avery, and K.A. Jacques. 1987. Kansas Ag. Exp. Sta. Rep. of Prog. 514.

109. Vanzant, E.S., R.C. Cochran, A.A. Beharka and T.B. Avery. 1988. Kansas Ag. Exp. Sta. Rep. of Prog. 539.

110. Vogel, G.J., M.A. Andersen, and G.W. Horn. 1987. Okl. Anim. Sci. Res. Rep. MP-119.

111. Vogel, G.J., G.W. Horn, W.A. Phillips, C.A. Strasia and J.J. Martin. 1989. Okl. Anim. Sci. Res. Rep. MP-127.

112. Ward, J.K. 1983. Proc. Range Beef Cow Symposium VIII. Sterling, CO.

113. Ward, J.K. 1989. Neb. Beef Cattle Rep. MP-54.

114. White, R.G., D.L. Ferguson, J.T. Nichols and D.C. Clanton. 1977. Neb. Beef Cattle Rep. EC 77-218.

115. White, T.W., F.G. Hembry, P.E. Humes and A.N. Saxton. 1987. J. Anim. Sci. 64:32.

116. Wilkerson, V., F. Goedeken, R.T. Brandt, Jr. and T. Klopfenstein. 1986. Neb. Beef Cattle Rep. MP-50.

117. Winder, J.A., K.S. Lusby, D.R. Gill and T.L. Evicles. 1983. Okl. Anim. Sci. Res. Rep. MP-114.

Brittany J. Bock
Agway Inc., DeWitt, NY

Scott M. Hannah
Extension Assistant, Livestock
Kansas State University

Frank K. Brazle
Extension Specialist, Livestock
Production, Southeast

Larry R. Corah
Extension State Leader
Animal Sciences and Industry

Gerry L. Kuhl
Extension Specialist
Beef Cattle Nutrition and Management

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

C723 June 1991

File code: Animal Science 2,3,4