Evaluating Reproductive Efficiency in Beef Cattle Herds

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Unlike the dairymen, beef cattle producers derive most of their income from calves born into the herd, making fertility the most important trait of beef cattle. A recent economic study showed that fertility was 5 times more important than the next important disease condition in cattle (Table 1). Another study also showed that fertility was 5 times more important than growth rate and 10 times more important than carcass quality.[1]

TABLE 1. Disease Conditions of Cattle and Estimated Loss in Millions in the U.S.[a].

Disease Condition	Estimated Annual Loss in $ Million
Bovine reproduction failure	2560
Respiratory disease	500
Calf scours and enteric disease	400
Mastitis	368
Stomach and intestinal nematodes	337

[a] ARS National Research Program, NRP No. 20420, October 1976, USDA, ARS

There were 37 million beef cows of reproductive age in the United States in 1983 and yet only 27.4 million calves were weaned, or 74% of the total possible.[2] Data from research station beef herds indicate that net calf crops are approximately 71%. Cows not pregnant at the end of the breeding season accounted for 17.4% of the losses, which together with prenatal deaths (6.4%), death from birth to weaning (2.9%) and fetal deaths (2.3%) reduced the potential net calf crop by 29%.[3] In another study, utilizing 8,184 beef cows and heifers, which had been on a routine reproductive herd health program for at least 10 years, 10% were not pregnant.[4]

Calf loss translates directly into economic loss. If a rancher weans calves weighing 500 lbs but only 75% of the cows, exposed to bulls, wean a calf, his weaning weight averages 375 lbs compared to 475 lbs if he weans calves from 95% of his calves. For 100 cows, this amounts to about $8,500 at today's market prices.

Wiltbank's work is based on economics of pounds of calf weaned over a lot of nonproducers, (i.e., bulls and replacement heifers) since they must be fed as well. His results show that only those cows weaning at least 500 lbs of calf in 210 days are profitable.[5]

The necessary selling price per hundred weight to break even with various calf crops (at weaning), and average weaning weights, assuming an annual cow cost of $225 are shown in Table 2. If a producer weaned an average of 450 lbs of calf with an 80% calf crop, his weaning weight is 360 lbs/cow. If the annual cow cost is $225 divided by 360 lbs of calf/cow the break even price is $62.49/cwt ($225 annual cow cost/360 lbs calf/cow = $62.49). Assuming a national average of 74% most of the cattlmen in the United States have not been economically sound until this year.

Ideally, cows should wean calves that weigh 50 to 60% of the dams' weight. In order to do this calves must be born early in the calving season.

TABLE 2. Necessary selling price per hundredweight to break even with various percent calf crops and average weaning weights assuming an annual cow cost of $225.

Calf Crop (weaned)	Average Weaning Weights 350	400	450	500	550
100	64.29	56.25	50.00	45.00	40.91
90	71.43	62.49	55.56	50.00	45.45
85	75.75	66.18	58.91	52.94	48.18
80	80.36	70.32	62.49	56.25	51.14
70	91.83	80.36	71.43	64.32	58.44

Veterinarians in private practice have a greater opportunity than any other resource to help producers overcome herd reproductive performance short comings. Practitioners can influence the reproductive efficiency of beef herds by expanding their activities beyond the traditional services of pregnancy diagnosis and bull semen evaluations. This can be done by a more total herd production management involvement that encompasses identification and correction of management and nutritional deficiencies.

Most herd disease and production problems are of multifactorial causation and many are primarily determined by management practices and reproductive efficiency. In order for practitioners to increase a beef producer's income the practitioner must be familiar with the causes of, and methods to increase, reproductive efficiency.

Nutrition

Due to poor nutrition a significant proportion of lactating cows in many beef herds have not ovulated by the beginning of the breeding season, or even at the end of the breeding season in some herds.[4] A negative energy balance after calving inhibits estrus and lowers conception rates in cows that calve in this condition.[6] First-service conception rates

were 43% for the cows that lost weight and 67% for those cows that had no change between calving and breeding.

The amount of digestible nutrient intake is important in the prepartum and postpartum periods, but it is thought to be most critical in the last trimester of gestation.[7 8] Inactive ovaries and uterine atrophy due to nutritional deficiencies, primarily energy, are seen most commonly in nulliparous heifers (18-24 months of age), primiparous heifers (30-36 months of age) and multiparous cows 9 years and older (Table 3).[4]

TABLE 3. Nonpregnant Heifers and Cows by Age Group[b].

Condition	Group 1 (18-24 mo) n (%)	Group 2 (30-36 mo) n (%)	Group 3 (4-9 yr) n (%)	Group 4 (>9 yr) n (%)
Noncycling-nonpregnant	189(87.1)	169(53.3)	27(10.0)	70(69.3)
Cycling-nonpregnant	28(12.9)	134(42.3)	124(68.9)	29(28.7)
Pyometra, metritis	0(0.0)	14(4.4)	29(16.1)	2(2.0)
Total	217(100.0)	317(100.0)	180(100.0)	101(100.0)

[b] Mickelsen, WD, et. al: JAVMA 189:52, 1986.

Insufficient nutrition can delay puberty. Although puberty is affected by age, breed and climate, [7 8] delayed puberty in heifers is also caused by deficient digestible energy intake.[9]

Body condition at calving greatly influences the length of time from calving to first estrus.[10] By 60 days post calving, estrus had been observed by 91% of cows that calved in good body condition as compared to only 46% of cows that calved in thin body condition.[11] Observation of cow condition at pregnancy examination has shown a significant reduction in days pregnant as body condition decreases.

Body condition scores (BCS) correlate highly with total carcass energy content in beef cattle.[12] Body condition scores are basically measurements of body fat estimated by palpation of the fat cover over the transverse processes of the lumbar vertebra and the tailhead region. Lowman has decribed 6 categories, numbered 0 to 5.[13] Another body condition scoring system utilizes 9 separate classifications.[14] Adding one-half increments to the Lowman system results in a comparable scoring system. Decisions of beef cattle nutritional management between pregnancy examination and calving can be made utilizing 3 categories of BCS. Most noncycling nonpregnant cows with ovaries that measured less than 2 x 0.5 x 0.5 cm and contain no functional structures[15] have body condition scores of 2 or less (Lowman system). They are thin cows with the individual transverse processes rounded rather than sharp and have no fat over the tailhead.[13]

For each half point (Lowman system) or one full point (Texas body condition scoring system) requires a change of 80 lbs. The target BCS for beef cattle, utilizing Lowman's scoring system, are 2.5 to 3 at breeding (individual transverse processes can only be felt with very firm pressure and some fat cover around the tailhead), 3 at pregnancy examination and 3 to 3.5 at calving.

Analysis of nutrients, especially energy, can then be accomplished. The determination of phosphorus, copper and selenium levels should be routine when investigating herd fertility problems. First lactation heifers should be chosen to assess internal parasitism. They are more likely to reflect the herd worm burden than cows. Cows have a more developed immune system that inhibits damage and egg laying by nematodes.[16]

Breeding Schedule

Breeding season length has a great influence on herd reproductive performance. Sixty-three days is recommended for cow herds. Longer breeding seasons, up to 5 months, as practiced by many large cattle operations in the Northwestern United States, are management deficiencies that result in a lack of selection for reproductive efficiency. Thirteen- to 15-month-old heifers should be mated for 42 days and rebreeding should begin 2-3 weeks prior to the cow herds so as to assure earlier rebreeding in future seasons. Although shortening the breeding season may result in cash flow problems the first year, overall the results of shortening the breeding season indicates that net calf crop, actual weaning weight and total weight of calf weaned per cow all increase.[17]

Reproductive Culling Program

A culling program, at pregnancy examination, that removes from the herd cows that are nonpregnant or which will calve late has proven to increase herd fertility through selection pressure for reproductive efficiency. The pregnancy ratio of a commercial crossbred herd increased from 44 to 94% in 7 years by eliminating all nonpregnant cows at the end of each breeding season.[18]

Older cows which lack incisor teeth are good candidates for culling as there is a higher death loss in this age group due to the stress of parturition and rearing a calf. There is also a high percentage of nonpregnant animals in this age group. If shortened breeding seasons are not practiced the late calving cows can be eliminated by estimation of gestation at pregnancy examination. A Canadian study revealed that when cows were examined for pregnancy and nonpregnant cows were culled, as compared to no previous pregnancy examination, the weaning percentage for cows retained increased from 84.3% to 92.1%.[19]

Dystocia

Among cows experiencing dystocia (14.4%) fewer were detected in estrus during the breeding season than those with no dystocia. For all cows, dystocia lowered conception rates 15.9%.[20]

Dystocia occurs more frequently in primiparous heifers and is a major cause of beef-calf mortality, accounting for 72% of the anatomically normal calves lost at or shortly after birth.[20 21]

Calf birth weight is the single most important factor associated with dystocia. The correlation between calving-ease scores and birth weight is .53, .41, and .11 for 2-year-old, 3-year-old and mature dams, respectively. The correlation between birth weight of a bull and the calving-ease score in a cow is .89-.97.[22] To reduce dystocia, heifers should be bred to a bull that weighed < 75 lbs at birth.[23]

The second stage of labor, when the calf enters the birth canal, averages 22 minutes in cows and 49 minutes in heifers. Each 10 minute increase in duration of labor lengthens the interval between calving and the first postpartum estrus by 2 days and reduces the percentage of females exhibiting estrus during the first 21 days of the breeding season by 7%.[20]

Dam pelvic size, as measured by calipers, is the second most important factor in dystocia. Pelvic measurements may be taken at prebreeding or pregnancy examination. Beef heifers with pelvic areas in the lower 20-30% of the replacements should be culled.[24]

Insufficient nutrition can delay puberty, lower conception rates, decrease skeletal muscle growth and increase the frequency of dystocia.[20 25] Because large birth weights result in an increased frequency of dystocia, it is sometimes believed that reducing the amount of feed during pregnancy will slow the growth rate of calves *in utero,* resulting in lower birth weight and decreasing the probability of dystocia. However, research does not support this conclusion.[26 27] In fact, decreased nutrition tends to increase the frequency of dystocia,[20 28] increase calf deaths[21 25] and decrease subsequent reproductive performance in dams.[21 26 27]

Trials have proved that early assistance in delivering calves results in reduced perinatal calf losses and improved future reproductive performance.[25] Early assistance is defined as an aid in delivery as soon as the cervix is fully dilated, regardless of potential dystocia. When females in labor are found with fetal membranes or feet extending from the vulva, they are immediately assisted. It should be stressed to producers that if the birth canal is entered, clean sanitation must be maintained to avoid infections.

Reproductive Tract Infections

Several infectious agents have been documented as causing impaired fertility through conception failure or embryonic mortality. In one large herd survey, however, nonspecific endometritis had a low incidence in beef cows (<1%).[4] This may be due to multiple nursing by calves with subsequent release of oxytocin as compared to dairy cows with only 2-3 times a day milking.

The venereal diseases campylobacteriosis and trichomoniasis, which are common in beef herds, probably cause the greatest losses. Prevention of control of infections by these organisms is based on breeding management (trichomoniasis) and immunizations (campylobacteriosis). Culture for trichomoniasis should be considered for all bulls over 4 years of age as a routine part of the breeding soundness examination.[29]

Bull Evaluations

In a Nebraska trial using breeding soundness evaluation (BSE) criteria, the first-service conception rates for bulls classified as satisfactory, questionable, and unsatisfactory were 60, 48 and 30%, respectively.[30] Untested bulls had a 51% conception rate, 9% less than satisfactory tested bulls. Assuming a calf average daily gain of 1.7 lbs, satisfactory bulls would increase weaning weights by 174 lbs compared to progeny of untested bulls. At $17 per cow[31] times 20 cows, the average number of cows placed with a bull in the Northwestern United States, this amounts to $340 per bull over untested bulls.

Bulls should be evaluated annually, prior to the breeding season, using the criteria suggested by the Society for Theriogenology.[31] The score is composed of scrotal circumference (<40%), sperm motility (<20%) and sperm morphology (<40%). These 3 criteria are significantly correlated with pregnancy rates of bulls in natural service. Increases of 5 to 6% in conception rates were found in herds with extended breeding seasons and utilizing a multiple-sire, natural-mating program.[32] Only bulls with adequate scrotal circumference and greater than 70% morphologic normal sperm were used.

A Canadian study revealed that when bulls were given a BSE prior to breeding, as compared to none in previous years, the pregnancy rate increased by 3.5% while the breeding season was shortened, calf weaning weights increased, and the bull to cow ratio was increased from 1:20 to 1:30.[19]

Bulls with a large scrotal circumference produce more semen, have a higher prevalence of morphologically normal sperm and have greater sperm motility than bulls with small scrotal circumference.[31 33] Age of heifers at puberty is correlated with the scrotal circumference of the sire. Heifers sired by bulls with a larger than average circumference tend to reach puberty earlier than do daughters of bulls with a small scrotal circumference.[31 33] When practitioners investigate the role of bulls in herd fertility it is important that libido, serving capacity and social interactions be included. Two studies have demonstrated that libido scores are more highly correlated with pregnancy rates than semen scores.[32 34]

Studies have shown that older bulls in the herd become dominant and may sire 60 to 100% of the calves.[35 36] Dominance is mainly dependent on seniority and age. Pregnancy rates in a herd could be severely reduced if an older dominant bull became infertile due to illness or injury, therefore, producers that will not agree to annual prebreeding examinations of all bulls should be strongly encouraged to include older bulls with the group selected for a BSE.The routine culling of bulls over the age of 4 or 5 years of age should be recommended because of the dominance trait and

the increased possibility of spreading trichomoniasis in this age group.

Crossbreeding

The producer must evaluate the market place and decide upon a strategy that provides the greatest opportunity for economic survival. Purebred cattle producers are faced with a major marketing problem. Seventy years ago 12 to 15 breeds were in direct competition for this market and the majority of the market involved only 4 breeds. Today over 40 breeds of cattle are available for use in the beef industry. Breed differences can best be exploited by crossbreeding which also provides heterosis. Weaning weight per cow exposed to breeding was increased 80 lbs (23%) from the combined efforts of heterosis on survival and growth of calves, and by increased reproduction and milk production on F_1 cows.[37] More than half of the increased performance was due to the crossbred cows. In the western United States the Hereford x Angus cows consistently produces more pounds of calf and becomes pregnant earlier the next breeding season than purebred cattle of either breed.

High levels of heterosis are maintained from one gestation to the next by rotational systems of crossbreeding. Results indicated that heterosis should increase weight of calf weaned per cow by at least 15% with two-breed rotational systems and by at least 20% with three-breed rotational systems of crossbreeding.[38]

While crossbreeding provides for great use of heterosis, large genetic differences in performance levels tend to be restricted because of additive genetic composition. Thus, it is important for rotational systems to use breeds that are reasonably comparable in characteristics such as birth weight, size and lactation potential and well adapted to the feed and other production resources in the operation.

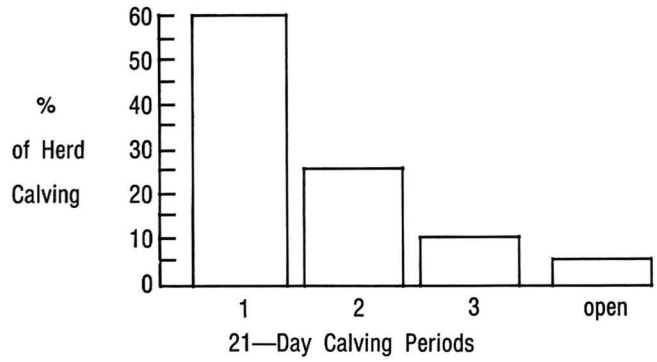
Data Analysis

Examination of the producer's records are important in establishing epidemiologic patterns of the herd's fertility. A calving histogram is a bar graph representing the percentage of the herd that calves each 21 day period of the calving season (Figure 1). It can be made from a producer's calving records or predicted from fetal ages estimated at pregnancy examination.

The goal is to have 63% of the cows calve in the first 21 day period.[39] Herds under excellent management calve up to 75% of the cows during the first 21 day period[40] and a 95% pregnancy rate in a 63 day breeding season. Failure to reach these goals results in losses of product evidenced by decreased weaning weights per cows exposed for breeding.

Evaluation of the patterns of calving histograms can aid in diagnosing causes of impaired fertility. The calving histogram of a herd affected by infectious diseases, such as campylobacteriosis or trichomoniasis, and herds with inadequate nutrition are both characterized by low pregnancy percentages for each 21 day period of the breeding season.[39]

FIGURE 1. Ideal calving histogram for a beef cattle herd[a].



[a] Spire M, Proc Soc for Theriogenology, 1984, p 19.

Separate calving histograms should be made for the whole herd, cows that were dry the previous year and first lactation heifers.

A sample calving pattern is listed in Table 4. In this study comparing program 1 (no reproductive herd health program) to program 2 (reproductive herd health program) more cows and heifers calved earlier in the calving season.[19]

In addition, cattle can be examined rectally to confirm some of the findings. Noncycling cattle due to nutritional problems are characterized by ovarian inactivity (i.e., ovaries 2 x 0.5 x 0.5 cm) with no functional structures. The uterus in these cows is usually small, with uniform thinning of the walls and atonicity is a common finding.[4] In cows affected by dystocia, trichomoniasis, campylobacteriosis and subfertile bulls the uterus is palpably normal and the ovary contains a functional corpus luteum.[4]

TABLE 4. Calving pattern of cows that calved as an indicator of early conception in breeding season.[c]

	Calving Pattern			
	Program 1 1980		Program 2 1986	
	1st calf heifers	cows	1st calf heifers	cows
% born				
1st cycle	57.8%	32.7%	78.4%	65.8%
2nd	34.5%	46.9%	21.6%	29.2%
3rd	6.5%	17.8%	0%	5.0%
4th	1.2%	2.6%	0%	0%

[c] Prince DK, et al: Bov Prac. 1987.

Conclusion

Reproductive efficiency can be increased by evaluating management practices that affect body condition of cows, breeding schedules, proper culling, dystocia rate, cross breeding and bull performance. In addition, evaluating reproductive tract infections, analysis of calving pattern histograms and reproductive trait examinations may be steps to increase total herd production management. A Canadian

study revealed that when a reproductive herd health program was instigated 206 more calves were weaned from 240 fewer cows as compared to previous years resulting in an 11.9% increase in total income.[19] A 5% increase in the United States calf crop would increase gross profits to the beef industry by > $1.7 billion annually.[41]

References

1. Trenkle A, William RL: Beef production efficiency. Sci 198:1009-1015, 1977. 2. Western Livestock Roundup, Cooperative Extension Service, Washington State University, Pullman, WA 1983. 3. Bellows RA, Short RE, Staigmiller RB: Research areas in beef cattle reproduction. Beltsville Symp Agri Res 1979, 3-18. 4. Mickelsen, WD, Paisley, LG, Anderson, PB: Survey of the prevalence and types of infertility in beef cows and heifers. JAVMA 189:51-54, 1986. 5. Wiltbank JN: Improving and predicting reproductive performance. Bov Pract 19:164-178, 1984. 6. Wiltbank JN, Rowden WW, Ingalls JE, et al: Influences of post partum energy level on reproductive performance of Hereford cows restricted in energy intake prior to calving. J Anim Sci 23:1049-1053, 1964. 7. Corah TD, Dunn TG, Kolterback CC: Influence of prepartum nutrition on the reproductive performance of beef females and the performance of their progeny. J Anim Sci 41:819-824, 1971. 8. Dunn TG, Ingells JE, Zimmermann DR, et al: Reproductive performance of 2-year-old Herefords and Angus heifers as influenced by pre- and postcalving energy intake. J Anim Sci 29:719-726. 9. Laster DH, Glimip HA, Gregory KE: Effects of early weaning on postpartum reproduction of cows. J Anim Sci 36:734-740, 1961. 10. Spitzer JC: Influences of nutrition on reproduction in beef cattle. In, Current Therapy for Theriogenology 2, pp 320-341. 11. Whitman RW, Remenga EE, Wiltbank JN: Weight change, condition and beef cow reproduction. (Abstract) J Anim Sci 40:387, 1975. 12. Dunn TG: Selection and management of the beef cow herd. Proc Soc for Therio 1984, pp 137-157. 13. Foreman BG, Scott N, Somerville S: Condition Scoring of Cattle. E. Scotland College Agric Bull No 6 (Revised ed), 1976. 14. Herd DB, Sprott LR: Body condition, nutrition and reproduction of beef cows. Texas Agri Ext Service Bull 1526. 15. Zemjanis R: Diagnostic and Therapeutic Techniques in Animal Reproduction. 2nd ed, Baltimore, Williams and Wilkins, 1970. 16. Wikse SE: Investigation of impaired fertility in beef cattle herds: Part II. The herd investigation. Comp Cont Ed (in press), 1988. 17. Radostits OM, Blood DG: Herd Health. Philadelphia, WB Saunders Co., 1985, p 213. 18. Fields MJ, Warnick AC: Factors affecting calf crop percentage. Southern Regional Beef Cow-Calf Handbook, 1003. 1-1003.5, 1978. 19. Prince DK, Mickelsen WD, Prince EG: The economics of reproductive beef herd management. Bov Pract (in press), 1987. 20. Bellows RA, Short RE, Aderson DC, et al: Cause and effect relationship associated with calf difficulty and calf birth weight. J Anim Sci 33:407-415, 1971. 21. Bellows RA, Short RE, Richardson GV: Effects of sire, age of dam and gestation level on dystocia and postpartum reproduction. J Anim Sci 55:18-27, 1982. 22. Sire Selection: In Commercial Beef Cattle Production. Philadelphia, Lea and Febiger, 1978, p 114. 23. Makarachian M, Berg RT: A study of some of the factors influencing ease of calving in range beef heifers. Can J Anim Sci 63:255-262, 1983. 24. Deutscher GH: Using pelvic measurements to reduce dystocia in heifers. Modt Vet Pract 10:751-755, 1985. 25. Bellows, RA: Calving management. Proc Soc for Therio, 1984, 145-147. 26. Patterson DJ, Bellows RA, Burfening PJ: Effects of caesarean section, retained placenta, and vaginal or uterine prolapse on subsequent fertility in beef cattle. J Anim Sci 53:916-921, 1981. 27. Brinks JS, Olson JE, Carroll EJ: Calving difficulty and its association with subsequent productivity in Herefords. J Anim Sci 36:11-17, 1973. 28. Rice LE, Wiltbank JN. Factors affecting dystocia in beef heifers. JAVMA 162:1347-1348, 1978. 29. Ball L, Cheney JM, Mortimer RG, et al: Diagnosis and control of herd infertility in beef cattle. Proc Soc for Therio 1983, 22-31. 30. Wiltbank JN, Rowden UN, Ingalls JE: Relationship between measure of semen quality and fertility in bulls mated under natural conditions. University of Nebraska News Bull, No 24, 1965, 3-19. 31. Ball L, Ott RS, Mortimer RG, et al: Manual for breeding soundness examination of bulls. J for Therio XII, 1983, 16-29. 32. Wiltbank JN: Evaluation of bulls for potential fertility. Proc Soc for Therio, 1982, 141-154. 33. Brinks JS: Genetic aspects of reproduction in beef cattle. Proc Conf Art Insem Embryo Transfer Beef Cattle, 1984, 28-31. 34. Chenoweth PJ: Bull fertility. Mod Vet Pract 61:987-991, 1980. 35. Blockey MA de B: Observations on group mating of bulls at pasture. Applied Animal Ethol 5:15-34, 1979. 36. Blockey MA de B: Value of serving test in breeding soundness examination of beef bulls. Vict Vet Proc 34:21, 1976. 37. Gregory KE, Cundliff LV: Crossbreeding in beef cattle. Evaluation of systems. J Anim Sci 57:1224-1242, 1980. 38. Long CR: Crossbreeding for beef production: Experimental results. J Anim Sci 51:1197-1223, 1980. 39. Spire MF: Breeding season evaluation in beef cows. Proc Soc for Therio, 1983, 15-21. 40. Rice LE: Reproductive health management in beef cows. In, Current Therapy in Theriogenology, ed 2, Philadelphia, WB Saunders Co, 1986, 400-40. 41. Mickelsen WD, Paisley LG: Infertility in beef cows. Mod Vet Pract 61:834-839, 1980.

Questions & Answers:

Question: Do you have a comment on the use of prostaglandin in a heifer breeding program?

Answer: There is a program where the bulls are turned out five days into the breeding season and giving the heifers a shot of prostaglandin with the idea that those in the early stages of the cycle and already bred would not respond and remain bred, most of the others would respond. Basically this looks pretty good. It is a fairly low cost program. It does not give you tight synchrony.