EB-95-01

HEIFER DEVELOPMENT: THE KEY TO A PROFITABLE COW HERD

Ron Torell, Gary Veserat, Bill Kvasnicka, Ken Conley, Les Krysil and Ben Bruce
University of Nevada, Reno
School of Veterinary Medicine

TABLE OF CONTENTS

Nutritional Management

When heifers are selected at weaning, that weight should be subtracted from the target breeding weight. This number should be divided by the number of days between weaning and breeding to arrive at gain required per day. For example, a heifer weighs 450 lb. at weaning and has a target breeding weight of 675 lb. Thus she needs to gain 225 lb. There are 180 days between weaning and breeding: 675 - 450 =225 ; 225/180 = 1.25 lb. of gain per day required.

This heifer would need to gain 1.25 lb./day to meet the target weight of 675 lb. Producers often wait until early winter to initiate a heifer development program. By doing so, the days on feed are shortened thereby increasing the ADG required to reach target weight. Feeding to high ADG's is OK if the target weight is achieved. It should not continue after reaching the target weight because fat is detrimental to heifer development. In addition, environmental conditions during wintering period may not allow for increased ADG unless concentrates are added to the ration. It is often more cost effective to feed a cheaper ration for a longer period of time. In Table 3, total digestible nutrients (TDN) and crude protein (CP) requirements for various gains are shown. There are many combinations of feedstuffs that can be used to achieve these gains. You should consider using one of the ionophores in a development program. Ample research points out that the use of ionophores in heifers results in earlier puberty due to increased weight gains and reduced feed per gain.

Table 3. Daily Nutrient Requirements for Developing Replacement Heifers from Weaning to Breeding[a,b]

	Weight[c] (lb.)	Daily Gain (lb.)	TDN (lb.)	CP (lb.)	Ca (g)	P (g)
Medium Frame	500	1.0	7.3	1.11	16	11
		1.5	8.3	1.25	21	12
		2.0	9.1	1.35	24	13
	600	1.0	8.4	1.19	17	12
		1.5	9.5	1.32	20	13
		2.0	10.4	1.41	23	14
Large Frame	500	1.0	7.3	1.16	17	11
		1.5	8.3	1.32	22	12
		2.0	9.1	1.46	26	14
	600	1.0	8.3	1.25	18	12
		1.5	9.5	1.41	22	13
		2.0	10.4	1.54	26	15
	700	1.0	9.4	1.34	18	13
		1.5	10.6	1.49	22	14

		2.0	11.7	1.61	25	15

[a]Adapted from NRC, 1984.
[b] Vitamin A should be in the diet at 1000 IU per lb.
Average weight during feeding period.

It should be emphasized that replacement heifers need to be fed separately from the rest of the herd. Because of their stage of growth and higher nutritional demands, they cannot compete with the rest of the cow herd nor efficiently utilize poor quality forages to meet their nutrient requirements (Table 4). Because of different objectives, they should also be fed separately from their steer counterparts if they are to cycle and conceive early in the breeding season.

Table 4.Occurrence of First Heat in Heifers on Two Levels of Feed Energy

Feed Level	Breed	Approx. Daily Gain (lb.)	11	12	13.	14 (mo.)	15	16	17
Low	Angus	0.9	0	0	0	33	82	90	100
	Hereford	0.6	0	11	22	33	38	50	100
	Crossbred	1.0	0	0	12	68	85	100	100
High	Angus	1.6	8	33	58	100	100	100	100
	Hereford	1.3	0	12	50	100	100	100	100
	Crossbred	1.9	0	18	75	94	94	100	100

Adapted from Wiltbank et al., 1969.

It is an old tale that "don't feed a high protein and energy diet before calving because the calf birth weight will increase and cause calving problems." Although you don't want to overfeed, meeting the heifers nutrient requirements during the last trimester of pregnancy will result in a stronger fetus, higher quality colostrum, and a stronger heifer that is capable of delivering a larger fetus and rebreed in 60 days.

BODY CONDITION SCORING

Introduction

Body condition is a term used by cattlemen and veterinarians to describe the nutritional status of a set of cows. The body condition scoring system has put a quantitative score on a procedure many cow-calf producers have long followed as a way of formulating sound nutritional programs. It has, however, provided more precise targets to maintain the productivity of today's

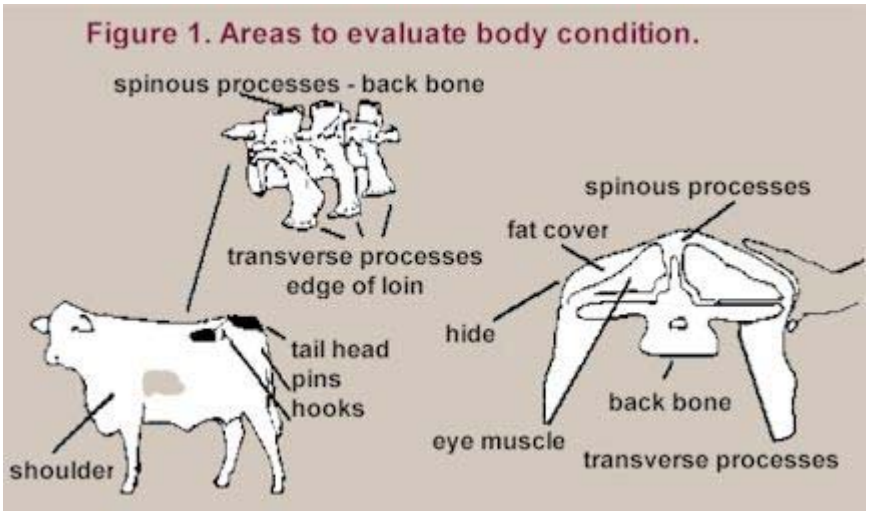
more productive beef cow.

Let's consider the practical use of body condition scores, but first address some key questions as they pertain to body condition.

- What is the body condition scoring system?
- Why are body condition scores important?
- Are they linked to reproductive performance?

The Body Condition Scoring System

The most commonly used system in the United States is one that ranges from 1 to 9 with a score of 1 representing very thin body condition and 9 representing extreme fatness. A cow with a body condition score of 5 should appear to be in average flesh and probably represents the target for which many cattlemen strive. Table 5 describes the nine-point body condition scoring system while Figure 1 shows areas to evaluate body condition.



The percentage of body fat in beef cows at specific stages of their productive cycle is important to their reproductive performance and overall productivity. Utilizing the body condition scoring system, we can plan winter supplementation programs to achieve the level of reproductive performance desired. Changes in body condition can be used as a guideline by cattlemen to accurately reflect the level of nutrition being received by cows without having to weigh them. Research has clearly indicated a strong link between body condition and weight change; thus, as body condition score drops or increases, weight changes will correspond.

Table 5. Body Condition Scoring (BCS) system for beef cattle

Group	BCS	Description
	1	EMACIATED -Cow is extremely emaciated with no palpable fat detectable over spinous processes (back bone), transverse processes (edge of loin), edge of hip bones or ribs. Tailhead and ribs project quite prominently.
Thin Condition	2	**POOR** - Cow still appears somewhat emaciated but tailhead and ribs are less prominent. Individual spinous processes are still rather sharp to the touch but some tissue cover exists along the spine.
	3	**THIN** - Ribs are still individually identifiable but not quite as sharp to the touch. There is obvious palpable

		fat along spine and over tailhead with some tissue cover over dorsal portion of ribs.
Borderline Condition	4	**BORDERLINE** - Individual ribs are no longer visually obvious. The spinous processes can be identified individually on palpation but feel rounded rather than sharp. Some fat covers ribs, transverse processes and hip bones.
Optimum Moderate Condition	5	**MODERATE** - Cow has good overall appearance. Upon palpation, fat cover over ribs feels spongy and areas on either side of tailhead now have palpable fat cover.
	6	**HIGH MODERATE** - Firm pressure now needs to be applied to feel spinous processes. A high degree of fat is palpable over ribs and around tailhead.
	7	**GOOD** - Cow appears fleshy and obviously carries considerable fat. Very spongy fat cover over ribs and around tailhead. "Rounds" or "pones" becoming obvious. Some fat around vulva and in twist (crotch).
	8	**FAT** - Cow very fleshy and over-conditioned. Spinous processes almost impossible to palpate. Cow has large fat deposits over ribs, around tailhead and below vulva. "Rounds" or "pones" are obvious.
Fat Condition	9	**EXTREMELY FAT** - Cow obviously extremely wasty and patchy and looks blocky. Tailhead and hips buried in fatty tissue and looks blocky. Tailhead and hips buried in fatty tissue and "rounds" or "pones" of fat are protruding. Bone structure no longer visible and barely palpable. Animal's mobility may even be impaired by large fatty deposits.

Richards et al., 1986. Journal of Animal Science, 62:300.

Body condition is also an excellent description of animals. For example, a cow with a body condition score of 3, and this will vary by breed, will often weigh 925 to 975 lb. (that estimate is applicable to cows of English breed type). She characteristically will show no fat cover as was previously described; her carcass, if slaughtered, would have approximately 9% fat (Corah, 1989a). In contrast, a cow of the English breed type with a body condition score of 5 (with the same frame size) will generally weigh between 1000 and 1075 lb.; her carcass will consist of 18% fat. In contrast, a score-7 cow will be in the range of 1200 to 1275 lb. with a body fat content of 27%.

Are Body Condition Scores Linked to Reproductive Performance?

Research in recent years has shown a relationship between body condition score and reproductive performance. At calving time, cows in varying body conditions differ greatly in the percent in heat at varying days postcalving (Table 6).

The relationship between condition score at calving time and resulting pregnancy rates is further

illustrated in Table 7. This study indicated that as body condition at calving increased, the percent pregnant at 40 and 60 days also increased.

Table 6. Body condition at calving and heat after calving.

BCS at calving	Number of Cows	Percent in Heat - Days postcalving	
		60	90
Thin(3)	272	46	66
Moderate(5)	364	61	92
Good(7)	50	91	100

Adopted from Whitman et al., 1975.

Table 7. Pregnancy in Santa Gertrudis Cattle

Score at calving	Condition			
	4	5	6	7
Number of cows	25	59	80	23
% pregnant after 40 days	8	24	46	70
% pregnant after 60 days	24	51	69	87

Adapted from Corah, L., 1989b.

Practical Use of Body Condition Scores:

It is essential that the body condition score at calving time allows the cows to be reproductively and economically efficient. This varies for each operation and is not the same in every part of the country. Typically, research data indicates that a body condition score of 5 at calving should be the target. However, some operators appear to get by with less, while others may need to achieve in excess of body condition 5 at this time. A score of 5 should be used as a target for mature cows; 2-year-old first-calf heifers may need to be 6 or more to compensate for the increased interval needed to cycle after calving.

It is important to remember that, though the early calving cow can be in a thinner condition, it is imperative that the late calving cow carry a little additional flesh if she's going to recycle and rebreed (Table 8).

Table 8. Effect of condition score on percentage of cows cycling.

Condition score	Number of cows	May	June	July
Early calving cows (Late March-Early April) March condition score (prior to calving)	----------%----------			
4	45	10.0	28.2	70.5
5	84	17.8	43.5	85.6
6	43	41.9	77.5	94.5
7	25	45.9	76.6	94.7
Late calving cows (Late April) March condition score (prior to calving)				
4	14	0.0	0.0	44.7
5	41	7.5	26.0	74.4
6	22	0.0	65.0	99.1
7	6	0.0	65.8	99.1

Corah, 1989a

according to age. Many cattlemen keep the 2-year-olds separated from the mature cows so they can feed the younger cows a higher plane of nutrition and enhance rebreeding. Another option cattlemen are pursuing is sorting through the mature cows and putting low body condition cows with the 2-year-olds. Thus, sorting by body condition is a management practice that can be done without having to weigh the cattle. By combining this practice with a 60 day breeding season it is easier to implement a timely nutrition program at critical stages of production.

Summary

Body condition scoring is a technique which is easy to make part of any cow-calf operation. Research clearly indicates that a certain body condition (5-6) is needed to have an optimum level of fertility in the herd.

PELVIC AREA MEASUREMENTS

Most calving difficulty is observed in first-calf heifers. The two major factors affecting calving difficulty are, first and most importantly, birth weight of the calf; and secondly, pelvic area of the heifer. Pelvic area is obtained by placing a pelvimeter and one hand in the rectum and measuring

width and height and multiplying the two measurements.

A typical yearling heifer will have a pelvic area of 140 to 170 sq. cm per day. For commercial producers, pelvic area measurements can best be used to identify heifers with small pelvic area where a large amount of calving difficulty might be expected. The cut-off used for identifying cull heifers will depend on breed and type of heifers and the expected birth weights of the bull to whom they are to be bred.

Selecting for larger pelvic areas should increase pelvic area in the herd, since heritability of pelvic area is quite high (approximately 55%).

Pelvic Measurement for Reducing Calving Difficulty.

Calving difficulty increases calf death loss, cow mortality, labor and veterinary costs. It delays the return of cows to estrus and reduces conception rates. Efforts to reduce calving difficulty often include selection of bulls that sire smaller birth weight calves. Smaller birth weight calves are usually smaller at weaning reducing profitability. However, expected progeny difference (EPD's) can be used to optimize birth weight and still have acceptable growth.

Studies show calf losses of 4 percent within 24 hours of birth for calves born unassisted, compared to 16 percent for calves requiring assistance. Montana research indicates 57 percent of all calf losses were due to dystocia (calving difficulty).

Calving difficulty is becoming a greater concern for beef producers because of increased emphasis on rapid growth rates, heavier weaning weights and improving cow efficiency. As producers select bulls indiscriminately for more growth, larger calves at birth and more calving difficulty can be expected.

Importance of Pelvic Measurements

Many factors are associated with calving difficulty, including: small-framed-first calf heifer; large fetus; male fetus; small pelvic size of dam; long gestation; heavy birth weight sire; dam too thin or too fat, and abnormal fetal presentation at calving. Research indicates the major cause of dystocia is a disproportion between the calf size at birth (birth weight) and the cow's birth canal (pelvic area).

An Oklahoma study showed calves born unassisted were seven pounds lighter at birth, compared to those born with assistance. Heifers with small pelvic areas experienced an 85 percent difficulty rate compared to 31 percent difficulty for heifers with large pelvic areas. South Dakota research showed heifers with below average pelvic area (less than 140 cm2) had twice the incidence of dystocia as those with above average pelvic areas (49 percent versus 24 percent). Similarly, University of Nevada research at the Gund Ranch revealed that heifers with pelvic areas below 140 cm2 had twice the incidence of dystocia (62% versus 34%) as heifers with larger pelvic areas. In addition, heifers with pelvic areas in excess of 150 cm2 only exhibited a 23% assistance rate.

Large frame cows tend to have large pelvic areas, but also have proportionately heavier calves at birth, which offsets any advantage of less calving difficulty. Selecting on cow size alone appears ineffective. A low relationship has been found between a heifer's pelvic area and the birth weight of her calf. Selecting heifers with a large pelvic size, rather than by body weight alone, should be advantageous and have minimal impact on calf birth weight. In general, heifer weight and age have a positive relationship to pelvic area, but weight is not always a good indicator. Two heifers

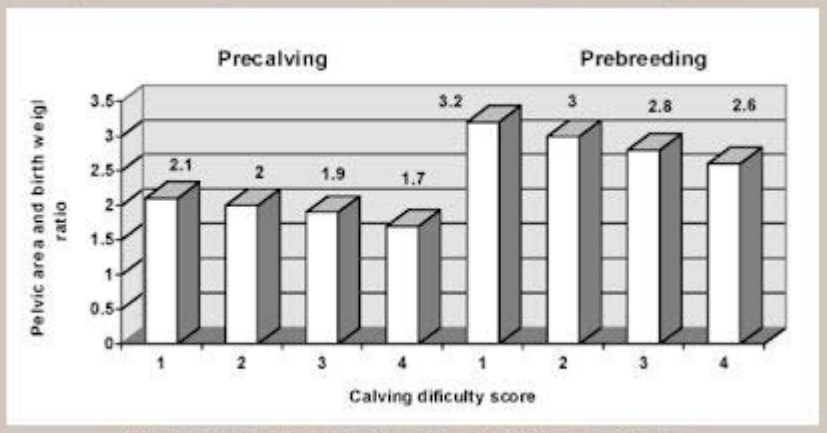
of equal weight can have considerably different pelvic areas.

External dimensions such as width of hooks and length of rump are not good indicators of pelvic area or calving difficulty. Neither are slope of rump and pelvic structure. Research shows that pelvic area has the most influence on dystocia of all cow measurements evaluated. Pelvic area has been found to be the most reliable yearling trait indicating potential difficulty. Studies show that pelvic area growth is linear from nine to 24 months in heifers calving at two years of age. Obtaining pelvic measurements on yearling heifers and culling those with small pelvic area can help reduce dystocia.

Pelvic Area and Calf Birth Weight Relationship

Research shows that calf birth weight in relation to the cow's pelvic area determines the degree of calving difficulty. Research data from South Dakota and Nebraska show a pelvic area and calf birth weight ratio factor. The ratio was derived by dividing the heifer's pelvic area by the birth weight of the calf she delivered. Figure 2 shows that as the ratios decreased, the degree of calving difficulty increased.

Figure 2. Pelvic area and calf weght ratios prebreeding and precalving in relation to calving difficulty scores.



(Scores were 1-no assistance, 2-slight assistance, 3-moderate assistance, 4-major assistance or C-section

Heifers with pre-breeding ratios of 2.1 or greater before breeding had little or no calving difficulty, while heifers with ratios of 1.9 or less required substantial assistance using a calf puller. If you know the birth weight, these ratios may be useful in predicting which heifers may require assistance delivering a certain size calf.

Pelvic measurements can be obtained on a heifer before breeding and the pelvic area divided by a ratio (factor) of 2.1 to estimate the calf birth weight the heifer can deliver as a two-year-old without having substantial difficulty. For example (Table 9), a 600 pound yearling heifer and a pelvic area of 140 cm2 should be able to deliver, as a two-year-old, a 67 pound calf without difficulty (140 divided by 2.1 = 67). Heifers with larger pelvic areas can deliver larger birth weight calves. However, a heifer with a smaller pelvic area such as 120 cm2 probably would require a Cesarean to deliver a 75 pound calf (120 divided by 1.6 ratio).

Table 9. Using pelvic measurements to estimate deliverable calf size (birth weight)

Time of Measurement	Heifer Age, Mo.	Heifer wt, lb.	Pelvic Area cm2	Pelvic Area/ Birth wt. Ratio	Estimated Calf Birth wt, lb.
Before breeding	12-13	600	140 160 180	2.1 2.1 2.1	67 76 86

Pregnancy exam	18-19	800	180 200 220	2.7 2.7 2.7	67 74 82
Deutscher, 1985.					

The ratio (factor) of 2.7 should be used to estimate calf birth weight of 18 to 19 month old, 800 pound heifers (Table 9). If heifers vary considerably in weight at the time of obtaining the measurements, different ratios should be used. Table 10 shows the ratios (factors) to be used for various weights and ages of heifers. These ratios appear to be good indicators of dystocia, with an accuracy of about 80 percent.

Table 10. Pelvic area/calf birth weight ratios for various heifer weights and ages to estimate deliverable calf birth weight

Heifer wt. lb.				
	8-9	12-13	18-19	22-23
500	1.7	2.0	-	-
600	1.8	2.1	-	-
700	1.9	2.2	2.6	-
800	-	2.3	2.7	3.1
900	-	2.4	2.8	3.2
1000	-	2.5	2.9	3.3
1100	-	-	-	3.4

Using Heifer Pelvic Measurements

If pelvic measurements are obtained before breeding, potential problem heifers with a small pelvic size can be culled from the herd. Since the larger, heavier heifers do not always have the largest pelvic area, all heifers should be measured and mated according to pelvic size.

Research indicates that a normal 600 pound yearling heifer should have a pelvic area at least 140 cm2 (11.5 cm wide and 12.5 cm high) to deliver a 67 pound calf. Heifers with a smaller pelvic area should be considered for culling.

Average pelvic area growth has been calculated at 0.27 cm2/day from yearling to two years of age in heifers, and continues at a slower rate until the cow reaches maturity. Some producers may wish to adjust pelvic areas of heifers to a standard 365 days of age. This can be accomplished by using the growth factor of 0.27 cm2/day. For a truly valid comparison, they must be adjusted and the adjustment is most accurate when measuring pre-breeding and adjusting to 365 days of age.

adjustment is warranted, since all heifers theoretically could become pregnant early in the breeding season and have about the same number of days to develop before calving. Heifers with small pelvic areas as yearlings usually have the smallest pelvic areas at calving.

Using Heifer Pelvic Measurements

Pelvic measurements should be taken two to three weeks before the breeding season and can be incorporated into a total heifer management program. This program involves selecting heifers for breeding by size and type, obtaining pelvic measurements, palpating for ovarian development (reproductive tract scoring, puberty), and vaccinating for reproductive diseases, all during one processing through the chute.

Such a program helps ensure that a high percentage of the heifers are cycling and could become pregnant early in the breeding season, and should result in reduced incidence of dystocia. This would also aid in an estrus synchronization and an AI program by determining the percentage of heifers cycling, and for reducing calving difficulty.

If heifers are measured at the time of pregnancy examination (measurement at 365 days is preferred), small-problem heifers could be culled, or aborted and sold as feeders. Bred heifers predicted to have a potential problem also could be marked for close observation at calving. Pelvic measurements, as a management tool, reduces calving difficulties on a herd basis works; but this practice will not totally eliminate all calving problems.

Heritability of Pelvic Area

Research estimates the heritability of pelvic area to range from 36 percent to 68 percent, with an average of 55 percent. These values indicate that pelvic area is a highly heritable trait and may be higher than the 45 percent heritability of calf birth weight. This means both traits will respond rapidly to selection. Birth weight does not appear to be correlated with pelvic area, so selection for pelvic size should not give a corresponding increase in birth weight. By selecting both bulls and heifers for acceptable pelvic size, a herd of cows with large pelvic areas could be developed.

Using Bull Pelvic Measurements

Pelvic size can be transmitted readily from the sire to the resulting progeny. In a Colorado study, a 0.60 genetic correlation was found between male and female pelvic areas, indicating selection for large pelvic size in bulls should result in increased pelvic size of daughter offspring. Nebraska research on 915 yearling bulls indicated only small differences in average pelvic size among breeds, but a large variation existed among bulls within a breed. For example, two yearling Simmental bulls of similar age and weight had pelvic areas that differed by 60 cm2 (160 vs. 220 cm2). Bulls of some blood lines appear to have larger pelvic areas than others.

Pelvic areas of bulls are smaller than heifers of the same weight and age. Yearling bulls weighing 900 to 1,100 pounds average about 150 to 170 cm2 in pelvic area, which is similar to yearling heifers weight 650 to 700 pounds.

Age and weight of bulls influence pelvic area. Estimates of pelvic growth rates in bulls have been 0.25 cm2/day of age and 0.09 cm2/pound of body weight in bulls ranging from 10 to 15 months old and 700 to 1,400 pounds. These values can be used to adjust a set of bulls to a given

standard, but both age and weight adjustments should not be used on the same bull. Pelvic areas should be adjusted to an average(preferably) age of bulls in the group so comparisons on genetic potential can be made.

Seedstock producers are beginning to report pelvic area of bulls along with other reproduction and performance traits. This information allows buyers to select bulls with various traits important to their herd, including pelvic area.

The best time to measure bulls is when they are yearlings, or at the end of their performance feeding test. The measurements can be obtained by a veterinarian in combination with the breeding soundness evaluation (fertility evaluation).

How to Measure Pelvic Area

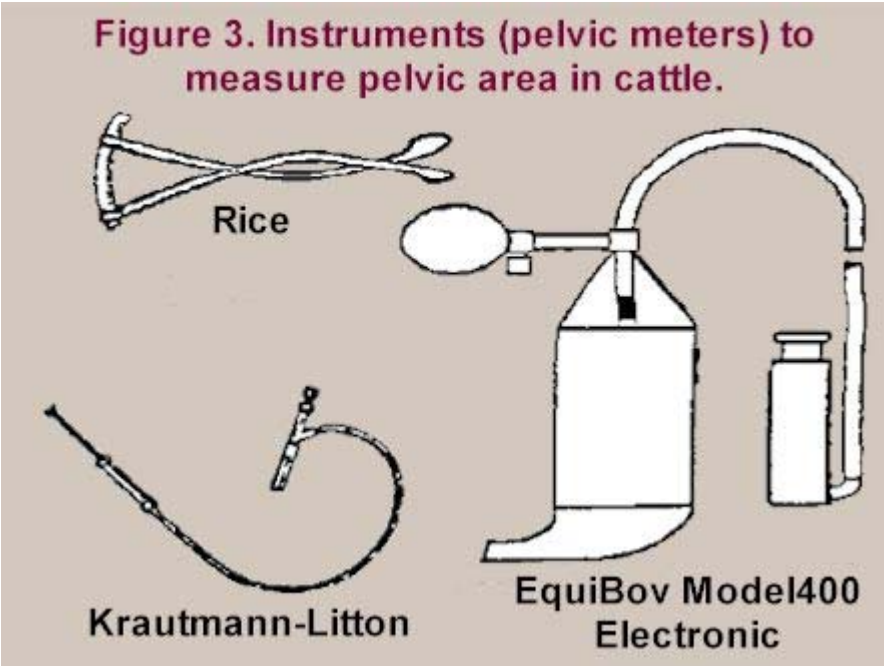
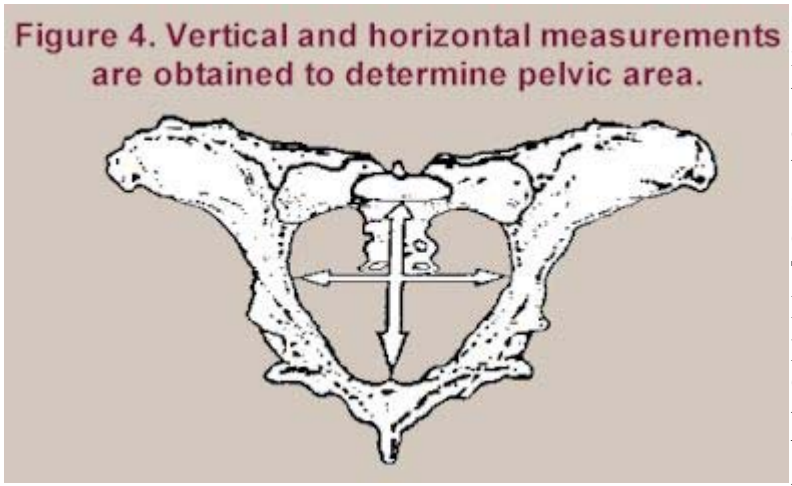


Figure 3. Instruments (pelvic meters) to measure pelvic area in cattle.

Pelvic measurements can be obtained with any of three instruments (Figure 3). The Rice Pelvimeter is a metal inside-caliper-type instrument (Lane Manufacturing, 1075 S. Balentia St, Unit C, Denver, Colorado 80231) available for about $130. The Bovine Pelvic Meter (Jorgensen Labs, Inc., 2198 West 15th St., Loveland, Colorado 80538) is a hydraulic-type meter with a cylinder connected to a recorder by a flexible tubing. This meter costs about $350. The EquiBov electronic pelvimeter (EquiBov, 205 Harris St., Rockwood, Ontario, Canada, N0B 2K0) comes with a digital display which automatically calculates pelvic area in square centimeters. The EquiBov retails for $550. Instructions for operating each of the instruments should be read and followed. Each instrument is designed to be placed in the rectum of the animal and the pelvic measurements are read on a scale outside the animal.

Measurements may be obtained by a veterinarian or experienced producer; a thorough understanding of the birth canal, pelvic structure and reproductive tract is needed. Practice and experience are necessary before accurate measurements can be obtained. Veterinarians in Nevada are providing the measurement service for a nominal fee ($1.25 to $3 per animal, depending on size of group). It is usually cheaper if done in conjunction with reproductive evaluation or pregnancy diagnosis.

The general procedure is to restrain the animal in a chute with light squeeze. A comfortable, normal standing position is best. Feces should be removed from the rectum and the instrument carefully carried into the rectum with the hand. Use of undue force should be avoided during the procedure, since tissues can be torn or injured. Proceed forward with the instrument to the pelvic inlet.



Obtain the height of the pelvic inlet, between the dorsal pubic tubercle on the floor of the pelvis and the sacrum (spinal column) on the top (Figure 4). Be sure to not slip off the pubic tubercle ventrad or miss the spinal column dorsad. This measurement should be the largest dimension between these points and is the vertical diameter of the pelvis. Obtain the width of the pelvic inlet at its widest point, between the right and left shafts of the ileum (Figure 4). This is the horizontal diameter of the pelvis. The two measurements are read in centimeters and multiplied together to give the pelvic area in square centimeters.

Conclusions

A reduction in calving difficulties can best be achieved by the management steps you take before mating. Here are some of the major points to bear in mind.

1. Heifer frame and pelvis size. Studies show that well-grown heifers with large pelvises tend to have fewer calving difficulties, provided nutrition during pregnancy is carefully monitored.
2. Sire selection. Studies show that through sire selection (using low birth weight EPD's), producers can match birth weight to heifer pelvic size. This method minimizes dystocia and optimizes weaning weights.
3. Choose a suitable bull breed. You can look for trouble if you mate large-framed, heavily muscled bull breeds with smaller, medium-framed yearling heifers.
4. Pelvic area is highly heritable. Selecting bulls with large pelvic area can increase pelvic size of heifer offspring.

REPRODUCTIVE TRACT SCORING

Introduction

Traditionally, most cattlemen have selected replacement heifers visually, according to size and appearance. In most cases, this subjective method of selection has not afforded sufficient focus on reproductive traits. The ability to identify heifers with the greatest reproductive potential prior to the breeding season should result in increased reproductive efficiency.

Age at puberty, defined as the age of first behavioral estrus, has been shown to be favorably associated with:

-
- pregnancy percent,
- percent calving the first 25 days,
- heavier calf weaning weights.

Research shows that early calving heifers have a higher average annual lifetime calf production than late calving heifers.

Reproductive Tract Scoring System

Reproductive tract scoring (RTS) is a method that can be used to increase reproductive efficiency which can positively increase profitability of cattle operations.

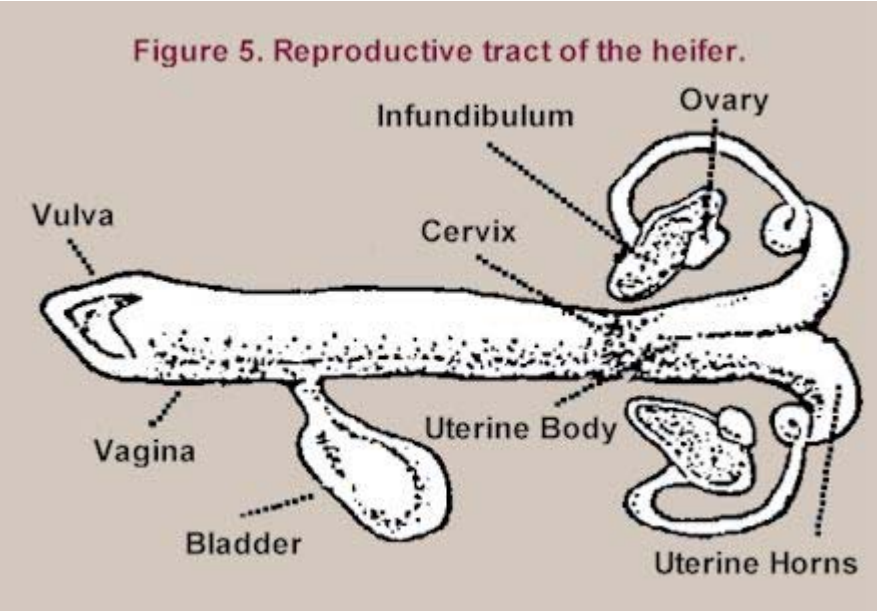
The RTS system estimates sexual maturity (puberty) via rectal palpation of the uterine horns and ovaries (Figure 5) as described in Table 11.

Table 11. Description of reproductive tract scoring[a,b]

Reproductive Tract Score	Uterine Horns	Length (mm)	Height (mm)	Width (mm)	Ovarian Structures
1	Immature < 20 mm diameter, no tone	15	10	8	No palpable follicles
2	20-25 mm diameter, no tone	18	12	10	8 mm follicles
3	25-30 mm diameter, slight tone	22	15	10	8-10 mm follicles
4	30 mm diameter, good tone	30	16	12	> 10 mm follicles, Corpus luteum possible
5	> 30 mm diameter, good tone, erect	>32	20	15	> 10 mm follicles, Corpus luteum present

[a] Adapted from K.J. Andersen, 1987. MS Thesis, Colorado State University, Fort Collins.
[b] Reproductive tract score was determined approximately 1 month prebreeding by rectal palpation.

A RTS of 1 is assigned to heifers with infantile tracts, as indicated by small, toneless uterine horns and small ovaries with no significant structures. Heifers scored as 1 are likely the furthest from cycling at the time of examination. Heifers given RTS of 2 are thought to be closer to cycling than those scoring 1, due primarily to the presence of small follicles (blister containing egg or ovum) and slightly larger uterine horns and



ovaries. Those heifers assigned a RTS of 3 are thought to be on the verge of cycling, based on slight uterine tone, in addition to the presence of follicles. Heifers assigned RTS of 4 are presumably cycling as indicated by good uterine tone, uterine size, and follicular growth; however, these heifers lack an easily distinguished corpus luteum (indicating they have cycled once), due to the stage of the estrous cycle. Heifers with reproductive tract scores of 5 are similar to those scoring 4, except for the presence of a palpable corpus luteum (showing they recently cycled).

Timing and Appropriate Use

The distribution of RTS's for a group of heifers depends upon when the heifers are examined. Variation within a group of heifers is temporary. If taken before 1 year of age, most heifers will not be cycling and will receive tract scores of 1 or 2. Conversely, if scores are taken too late, most heifers will be cycling and assigned scores of 4 or 5.

When tract scoring is to be used as a last minute culling tool, as an indicator of a heifer's ability to conceive early during the first breeding season, scoring should be done about 1 month or less before breeding. If used as a tool to place selection pressure on age at puberty, the best time to evaluate is when about half of the heifers are thought to have begun cycling based on age, weight, and casual estrus observation. If heifers are cycling more than 1 month before the start of the breeding season, they should be scored earlier while greater variation exists. A RTS taken 30 to 60 days prior to the start of the breeding season can also serve as a check for the heifers' nutritional development program. Then, according to the resultant scores, the ration or start of the breeding season can be adjusted. This will then allow you to begin the controlled breeding season when the heifers are most likely to become bred in 45 days or less.

Reproductive Tract Scoring and Reproductive Performance

Results from studies at Colorado State University indicate that reproductive tract scoring 1 month prior to breeding can help to identify those heifers less likely to respond to estrus synchronization and become pregnant during a short breeding season.

The relationship of RTS to reproductive performance information from a series of studies is presented in Table 12. Generally, Table 12 indicates a 5% to 22% advantage in pregnancy rate to synchronization for tract score of 4 and 5 versus tract scores of 3. Rates of pregnancy to synchronized breeding for RTS 1's were 41% to 58% lower than for RTS 4's and 5's.

Table 12. Average effect of reproductive tract score on reproductive trait means from various studies[a]

Reproductive Measurement	Reproductive tract score 1	2	3	4	5
Response to synchronization, %[b]	46.3	76.6	80.4	90.7	89.4
Pregnancy rate to synchronized breeding,, %[b]	2.6	22.6	39.5	54.6	55.0
Pregnancy rate at end of breeding season, %	28.2	74.2	76.8	94.1	85.0

Conception date, d[c]	19.0	10.0	2.0	4.3	0.0

[a]Data compiled from Brown, 1986, LeFever and Odde, 1986; Andersen, 1987; Anderson et al., 1987; Odde et al., 1989.
[b]Number responding or conceiving divided by the number treated at the start of the breeding season.
[c]Average conception dates represent the average number of days into the breeding season that conception occurred compared to the average of heifers that had reproductive tract scores of 5.

Differences in breeding season pregnancy rates for RTS's of 4 and 5, versus scores of 3, suggest anywhere from a 5% to 20%. Heifers with RTS's of 3 prior to the breeding season seem to have little advantage over RTS's of 2 in terms of pregnancy rates at the end of the breeding season. Heifers scoring 1 tended to have a dramatic 32% to 67% lower pregnancy rate at the conclusion of the breeding season than heifers scoring 3. These results indicate that heifers scoring 1 should be eliminated from the breeding group. Of heifers that conceived, conception dates for heifers with scores of 3, 4, and 5, were, on average, approximately 10 days earlier than heifers with an RTS of 1 and 2.

Palpation at 12 Months of Age

It is recommended that all heifers be rectally palpated at one year of age (Zollinger, per. comm.). Heifers bred on the third estrus are twice a s likely to conceive as those bred on the first. To have a higher probability of calving at 24 months, they need to settle at about 14 and have had the first cycle at 12 months. Any heifer with a small or malformed tract can be culled at one and not suffer p[rice reductions as with older animals. Three things should be evaluated: reproductive tract score, shape of pelvis and the size of the pelvic opening.

Discussion

Initially, widespread use of the reproductive tract scoring system depends upon overcoming special problems associated with this trait. It seems likely that veterinarians should be able to adapt to the scoring system and provide their clients with this useful service.

There is a positive relationship between sire scrotal circumference and daughters age at puberty. Many operations may already have high levels of fertility built into their herds if selection for large scrotal circumference of sires has been practiced. In such cases, RTS's may provide little additional benefit. Regardless of how inherent fertility is improved, through decreasing age at puberty from the mate and/or female side, it can be thought of as an insurance policy for expressed fertility. This should provide greater flexibility when matching mature size and milk production to management and environmental constraints. Breeding heifers 2-4 weeks before the cow herd permits concentration of time and labor on heifers during breeding and calving, and allows for a longer postpartum interval the following year to allow for repair and breed back of second calf heifers provided there is adequate nutrition during this period. If non-cycling heifers can be identified and eliminated from the breeding group, higher first service conception rates and other benefits of this management practice can be more fully realized.

Conclusion

In summary, RTS's have been found to be favorably associated with response to synchronization, pregnancy rate to synchronized breeding, pregnancy rate at the end of the breeding season, and conception date. Usefulness of the tract scoring system depends upon timing, previous selection practices, management, and environmental factors. Tract scores can be used to evaluate the status of heifer development, synchronization programs, the start of the breeding season, and place selection pressure on age at puberty and related traits. The scoring can be done in conjunction with collection of yearling weights, condition scores, pelvic

measurements, and general processing as part of a yearling heifer evaluation and health programs, include preparation for a 45 day breeding season as part of a heifer estrus synchronization program.

GROWTH PROMOTING IMPLANTS

Introduction

Growth promoting implantsa are used extensively in the finishing phase of the beef industry. In addition, implanting suckling and growing steers to increase weight gain is commonplace in the industry. If implants would be used to increase growth rate, increase skeletal structure, while not affecting reproduction, then they could be very advantageous in a heifer development program. Implanting breeding stock has generally been discouraged; however, research information on this topic is often conflicting. Implants for beef heifers

Numerous growth promoting implants are available to beef producers to use with heifers not being kept as breeding herd replacements (Table 13). Several are also approved for use on replacement heifers.

Table 13.Growth promoting implants for heifers

Trade Name	Company	Ingredients	Animal Use
Ralgro	Pitman-Moore Inc.	Zeranol (estrogenic)	Suckling and growing
Synovex-C	Syntex Agr. Bus. Inc.	Estradiol and progesterone	Suckling
Synovex-H	Syntex Agr. Bus. Inc.	Estradiol and testosterone	Growing
Compudose	Elanco Anim. Health	Estradiol and testosterone	Growing
Calf-oid	Upjohn	Estradiol and progesterone	Suckling
Implus-H	Upjohn	Estradiol and testosterone	Growing

Effects on Heifer Fertility

Considerable research has been reported on the effects of Ralgro implants on heifer reproduction (Table 14). Results of three studies when a Ralgro implant was given at birth provided ample evidence that heifers should not be implanted at or shortly after birth if they will be retained. A total 23 studies have been reported on single Ralgro implants given to heifers between 1 and 10 months of age (Table 14). Effects on yearling pregnancy rates are quite variable with 39% of the studies showing a positive effect, 22% showing no difference and 39% showing a negative effect. Of the 15 studies reporting on multiple implants (Table 14), 60% showed a negative effect, 7% showed no difference and only 33% showed a positive response. In addition, several studies showed considerable negative effect (-42 to -40%) on pregnancy rate. Researchers in Nebraska and Montana have indicated that the negative effects of Ralgro implants may be decreased in pregnancy rate if heifers are maintained on a high plane of nutrition (gaining 1.25 lb./day from weaning to breeding). Generally, replacement heifers in Nevada are not maintained on a high plane of nutrition.

Table 14. Summary of research data describing effects of various implanting regimens on pregnancy rate of yearling heifers.

Number of Studies	Age at Implanting	% difference in pregnancy rate for non-implanted versus implanted heifers	
Ralgro (single implant)		Average	Range
3	Birth	-37.0	-45 to -30
5	1 to 1.5 mo.	+0.4	-7 to +5
8	8 to 3 mo.	-1.6	-10 to +4
4	5 to 6 mo.	-2.0	-14 to +7
6	8 to 10 mo.	-1.3	-14 to +4
Ralgro (double implanted)			
9	1-3 and 4-6 mo.	-4.2	-40 to +11
3	6 and 10 mo.	-8.0	-22 to +6
Ralgro (multiple implanted)			
3	3 or more times	-22.7	-42 to -7
Synovex C (single implant)			
7	2 mo.	-1.7	-10 to +6
3	6 mo.	-3.3	-6 to -2
Synovex C (double implanted)			
2	2 and 6 mo.	-5.5	-11 to 0

Synovex-C is approved for use in suckling heifers that will subsequently become replacements. Limited research is available on the effects of this implant on yearling heifer reproduction. Yearling pregnancy rates varied from -10 to +6 with 57% of the studies showing a negative impact when heifers were implanted at 2 months of age (Table 14). Heifers implanted at 6 months of age resulted in 100% of the studies (3) showing a negative influence on reproduction. Only two studies have evaluated multiple implanting of Synovex C and indicated either no improvement or a negative impact on reproductive performance (Table 14).

Synovex-H and Compudose have a similar chemical make-up and are used in growing heifers. They are not approved for use in replacement heifers. Limited research on Synovex-H given at 6 months of age showed a negative effect on yearling pregnancy rates and puberty.

Calf-oid and Implus-H implants are relatively new and have the same chemical composition as the Synovex-C and Synovex-H implants, respectively. Early research indicates that Calf-oid and Implus-H implants have similar effects on heifers as the Synovex implants (Hixon et al., 1994).

Effects on Heifer Growth and Pelvic Area

In general, a Ralgro implant given at 1 to 2 months of age will increase weaning weights of heifer calves by 2 to 6% (10 to 30 lb.). However, this weight advantage declines by the time the heifer is a year of age. Puberty in heifers is the first behavioral estrus followed by ovulation and development of a corpus luteum. Heifers implanted with Ralgro exhibit a greater incidence of non-ovulatory estrus periods (false heats) than non-implanted heifers. However, research has indicated that if heifers are maintained on a high plane of nutrition to reach breeding weight, the negative impact on puberty is reversed. Research has shown the calving difficulty in 2-year-old heifers is inversely related to pelvic area. Many studies have shown that Ralgro increases pelvic area in heifers at weaning, at yearling or near breeding. However, pelvic area must be increased at calving to result in less calving difficulty. Studies from Nebraska, Kansas and Colorado indicate that by parturition non-implanted heifers had essentially the same pelvic size as implanted heifers.

A Synovex-C implant given at 2 mo. of age will increase weaning weights of heifer calves by 15 to 30 lb. which is similar to Ralgro. However, this weight advantage appears to continue to a year of age, which differs from Ralgro. It appears that the implants have little effect on the onset of puberty when heifers have a proper nutrition level. Nine studies have reported an increase in yearling pelvic area of heifers implanted with Synovex-C. However, most studies showed that this pelvic area advantage had decreased by calving and calving difficulty were not affected.

Summary and Recommendations

Despite the numerous studies conducted in this area, much remains to be learned about the effects of implants, but from existing research, the following recommendations can be made.

1. Both advantages and disadvantages of implants need to be considered and weighed on an economic basis before implanting calves.
2. If heifers to be saved for breeding can be identified early (before branding or working), then implanting them to increase yearling weight, early puberty or precalving pelvic area is a questionable practice. When buying replacement heifers, producers should learn the implant history prior to purchasing them. Multiple implants would never be recommended.
3. However, if replacement heifers cannot be identified until weaning time or later and calves are usually sold at weaning, then all heifers can be implanted once (preferably about 2 mo. of age; not at birth) to increase weaning weights and market value. Heifers kept as replacement must be fed adequately to reach target weights before the breeding season.

ESTRUS SYNCHRONIZATION

Introduction

The use of heat (estrus) synchronization is a management tool that can help range beef producers improve reproduction efficiency and economic returns. It should only be used on sexually mature (**CYCLING**) females. By synchronizing the estrous cycle, bulls can be used for a short, concentrated and controlled amount of time. Bulls should have passed a Breeding Soundness Exam (BSE) 30 to 60 days before the breeding season. It is possible in Nevada's range beef herds to obtain 80%-95% conception (heifers) during a 45-day breeding period using a synchronization program. In addition, breeding heifers 30 days before the mature cow herd allows first-calf heifers with adequate nutrition extra time the next year following calving to recover from nursing

a calf, accumulated body stress and prepare for rebreeding. Potential Benefits

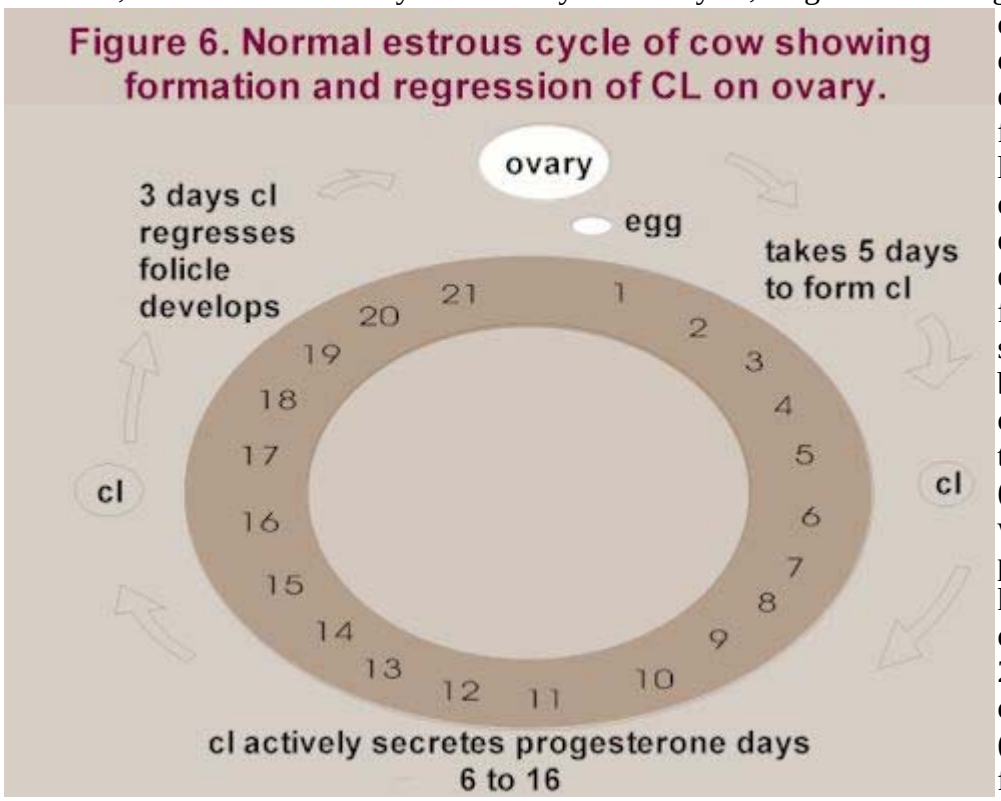
1. Shorter breeding seasons.
2. Concentrates breeding and calving seasons.
3. More uniform calf crop due to similar calf age. (Kansas research indicates uniform groups of 20 or more sell for an additional $4 - $6 per cwt.)
4. Heavier calves at weaning, because they are older.
5. More uniform management of cows, heifers and calves.
6. Better scheduling of labor in relation to main cow herd.

Potential Disadvantages

1. Must have **good management** and a planned program for successful results.
2. Heifers and cows must be cycling normally before treatment and on a good nutrition program with a Body Condition Score (BCS) of 5-6.
3. Cows need a minimum of 45 days post-calving before treatment.
4. Requires more intensified labor at breeding and calving time.
5. Need very active, healthy, disease free, fertile bulls for concentrated breeding.
6. Must allow for bad weather during concentrated breeding and calving periods over a 20 day span.
7. Requires adequate facilities and additional labor for handling cattle during treatment, breeding and calving.
8. Requires additional costs of synchronization product.
9. May require more bulls; but will certainly require good bull management.

Normal Estrous Cycle

In a herd of cycling cows or heifers, these females will exhibit estrus about every 21 days (range 18 to 23 days); with approximately 4%-5% in heat on any given day during the breeding season. However, at times this will vary. The 21-day estrous cycle, diagrammed in Figure 6, shows the corresponding changes that occur on the ovary: follicles (blister-like structure on ovary containing egg/ovum) produce estrogen to cause female to be sexually receptive by exhibiting "heat or bulling" (estrus); the corpus luteum (CL; yellow body) which produces progesterone and keeps the female out of heat. On day 21 standing estrus occurs. Ovulation (release of the egg from follicle on the



ovary) generally occurs about 12 to 18 hours following the beginning of standing heat. Following ovulation from days 2 to 5, development of the CL occurs at the site where ovulation took place. The CL is mature and fully functional by day 6, producing and secreting progesterone until day 17. If the cow is not pregnant, naturally occurring prostaglandins produced by the uterus causes the CL to regress (luteolysis decreases in size) and production of progesterone declines from days 17 to 20. During this period a new follicle (with the egg) is developing on the ovary for ovulation on day 1 and the cycle begins again.

Products and How They Work

Reference to a company or trade name does not imply approval or endorsement by the University of Nevada. Two types of products are currently approved by the FDA for effective use in estrus synchronization. They do not have adverse side effects on fertility or general health, provided the manufacturers' recommendations are followed (Table 15). The two types of products currently approved and available are 1) prostaglandins and 2) a combination of a synthetic progestin (Norgestomet) and estrogen (estradiol valerate). These two types of products work differently and are administered differently, so an understanding of their actions is necessary. Several management alternatives must be considered to fit the products and programs to a producer's operation and capabilities.

Table 15. Products for estrous synchronization[a]

Type	Product	Company	Administration	Dose
Prostaglandin	Lutalyse	Upjohn Co.	IM injection	25 mg
Prostaglandin	Estrumate	Mobay Co.	IM injection	500 mg
Prostaglandin	Bovilene	Syntex	SC injection	1 mg
Progestin	Syncro-mate B	Sanfoi-Ceva	Implant +	5 mg estradiol
+ estrogen			IM injection	3 mg norgestomet

[a]Cost of these products varies with Lutalyse, Estrumate and Bovilene ranging from $2 to $5; while Syncro-mate B ranges from $6 to $9. Synchronization products are available through your veterinarian.

A third type of product available, melengestrol acetate (MGA), is an orally active synthetic progestin product, which is currently not approved by the FDA for estrus synchronization. This product will be discussed later because of its potential use in range beef operations.

Prostaglandins

Prostaglandins are restricted by Federal law for use by or on the order of a licensed veterinarian. Women of child-bearing age, asthmatics and persons with respiratory problems should exercise extreme caution when handling this product. Also, be aware that **PROSTAGLANDINS WILL CAUSE ABORTIONS IN PREGNANT CATTLE.**

Currently there are three prostaglandin products on the market. Lutalyse and Estrumate have

been approved for use in both beef and dairy cows and heifers for estrus synchronization. Bovilene is currently approved for beef cattle and non-lactating dairy heifers only.

Prostaglandins regulate the female reproductive cycle by causing regression (luteolysis) of the CL, which is considered mature on days 6 through 17. Prostaglandins are ineffective on days 0 to 5 because the CL is not mature, nor is it effective from days 17 to 21 because the CL is not functional. However, CL regression is occurring during it's natural cyclic pattern, so this is not a concern.

There are a variety of programs that can be used with the prostaglandin products; however, only two programs will be discussed because of their feasibility in a range beef operation.

The single injection program (Figure 7), allows for fewer bulls to be used; however, it results in a decreased concentrated breeding and calving season. This program will cause approximately 60% of the females to cycle within 2-5 days after the single injection. The method is to simply run the open, cycling, females of adequate body condition down the chute and inject (I.M.) them with the prostaglandin product and turn them in with the bulls. The ratio of bulls to females should be 1:10 for younger, less experienced bulls to as high as 1:30 for mature, experienced bulls for the first 48-96 hours. Following the initial 96 hours of high sexual activity, the ratio can then be increased to 1:40 to 1:50. Artificial insemination may also be used with this program. Instead of putting females with bulls after the injection, heat detection could occur followed by A.I. Bulls could be put into clean up after 5-d of A.I.

Figure 7. Single injection system.

Prostaglandin System	
Inject prostaglandin, Turn in bulls	**High Sexual Activity**
Day 1	**Day 2-5**

The second program (Figure 8) utilizes a double injection method which will allow for a "tighter" synchrony of the females and thereby, a shorter breeding and calving season. This method will entail handling the cattle twice. This program should begin with open, cycling, cows or heifers of adequate body condition. All females should be given an injection (I.M.) of prostaglandin on Day 0, then 11 days later the second injection (I.M.) should be administered. The approximate number of females synchronized should be 85%-90% following this second injection. At the time of the second injection, the treated females are exposed to the bulls or artificially inseminated after heat detection. This program is more expensive and has application in a range operation were a higher percentage synchronized females is the goal.

Figure 8. Two shot injection system.

Prostaglandin System	
Inject prostaglandin	**Inject prostaglandin, turn in bulls**
Day 0	**Day 11**

Synthetic Progesterone Implant

This type of product combines the use of a synthetic progestin (Norgestomet) as an implant and an injection of estrogen (estradiol valerate). This product (Syncro-Mate B) will work at any stage of the reproductive cycle and it is a non-prescription drug for use in beef cattle and non-lactating dairy heifers. It works by regressing the CL and by blocking estrous activity in all stages until the implant is removed. The implant procedure is a two-step system (Figure 9) which requires administering a sub-cutaneous implant in the middle of the back side of the ear and an intramuscular (IM) injection of the estradiol valerate. Nine days later, the implant is removed from the ear, after which females will begin cycling within 1 to 2 days. Counting the day of implantation as Day 0, the implant must be removed on Day 9. A good rule of thumb is the Monday - Wednesday - Friday rule. If implantation is done on Monday, implant removal will be Wednesday of the following week and breeding will begin on Friday. **This product has the advantage of not causing abortion in pregnant animals**, but is more difficult to administer because of the implant insertion and removal. It can also induce estrus in some non-cycling females. It is also very important that the entire implant be removed or animals will not come into heat.

Figure 9. Implant System

Syncro-Mate B System		
Insert ear implant and give injection	**Remove implant**	**Turn in bulls**
Day 0	**Day 9**	**Day 12**

Oral - Progestin with Prostaglandins

The third type of product that has been used successfully in numerous range-beef operations (under a drylot situation) across the country is MGA (melengestrol acetate an oral synthetic progestin) with an injection of prostaglandin 17 days following withdrawal of MGA. MGA has been used in the feedlot industry for over 20 years to suppress heat in beef heifers and is available in feed supplement premixes you can purchase locally. Currently MGA is not labeled for synchronizing estrus in heifers; however, a label change is being sought. Use of MGA in this manner should be under the direction of a veterinarian.

The program utilizing the MGA/prostaglandin regimen, should begin 33 days (Figure 10) before the breeding season. Pre-feeding of a supplement without MGA should occur 3 to 4 weeks before beginning of MGA supplementation to ensure adequate consumption. This pre-feeding has another benefit, a "flushing" effect, caused by increasing the energy and nutrients to the females. Normally, animals are receiving supplemental feed at this time anyway, so supplementation at this time should fit into many management schemes. Adequate space must be provided to ensure that all heifers consume the required amount of MGA.

Figure 10. Feed supplement and injection system.

MGA/Prostaglandin System

MGA feeding peirod (14 days) Feed 0.5 mg/head/day	Sub-fertile heat	Inject prostaglandin, turn in bulls	Synchronized estrus
Day 1	14 16 20	31 33	36

This method requires feeding the premixed supplement of MGA (supplying 0.5 mg per head per day) for a period of 14 days, then following withdrawal of the MGA, a sub-fertile heat will occur within 4 to 7 days. Animals should not be exposed to bulls for the next 16 to 18 days following removal of MGA supplement. On the 16 to 18 day following withdrawal of the MGA supplement, an injection of prostaglandin is given to all females and they are turned with the bulls or artificially inseminated with heat detection or mass breeding 60 hours post-injection. Some recent research indicates that when bulls are used the injection of prostaglandin after feeding MGA should not be used (Hixon et al., 1994b). The peak sexual activity should occur from 48 to 96 hours following injection of the prostaglandin. Bull to female ratios are important. If mature, experienced bulls are used, then the male to female ratio should be 1:10 to 1:20. If the bulls are not mature or not in good condidtion, then more bulls should be used. Ideally, the bulls should be rotated every 12 hours during the first 2 to 3 days. Following the initial 96 hours, younger, less experienced bulls can be introduced to allow for rest of the older bulls at a ratio of 1:20 - 1:30. This program can result in 80%-95% of synchronized animals bred in a 45 day breeding season. In addition, some research data indicates that MGA may increase cycling rates in prepuberal heifers.

Colorado Studies compared the MGA/lutalyse system with the Syncro-Mate B program and concluded that the MGA/lutalyse program resulted in higher synchronized conception and pregnancy rates (Table 16). In addition, the MGA-Lutalyse system was cheaper and easier to apply in most heifer management programs.

Table 16. Estrous Response, Conception and Pregnancy Rates in Five Trials Comparing MGA-Lutalyse to Syncro-Mate B for Estrous Synchronization in Beef Heifers

	No. of heifers	Estrus Response[a]	Synchronized Conception Rate[b]	Synchronized Pregnancy Rate[b]
MGA + Lutalyse	157	83	69	57
Syncro-Mate B	153	90	41	37

[a]

[a]P < .10.
[b]P < .001
from Brown, et al., 1988.
Furthermore, Colorado also compared a 7 d MGA/Lutalyse program with the traditional 14 d MGA-Lutalyse program and concluded that the 14 d MGA-Lutalyse program provides better results (Table 17).

Table 17. Conception Rates and Pregnancy Rates after Synchronization with Two Different MGA-Lutalyse Combinations

Treatment	No. of heifers	Conception Ratea (%)	Pregnancy Rateb (%)	First 30 days of breeding season pregnancy rate (%)
14d MGA-Lutalyse	65	65c	50	78c
7d MGA-Lutalyse	64	42d	23d	64cd
Untreated control	64	45ce	8c	55d

[a]Conception rate is defined as the percentage conceiving of the number inseminated.
[b]Pregnancy rate is defined as the percentage conceiving of the to tal in the group.
[c,d,e]Percentages in the same column without a common superscript differ (P < .05). from Odde, 1987

REPRODUCTIVE DISEASES

Introduction

One of the greatest obstacles to optimal beef cattle production in the Great Basin region is failure of the brood cow to conceive and maintain the pregnancy to calving. Studies show that infertility and abortion causes a greater reduction in potential net calf crop than calf mortality after birth. The reproductive goals of a profitable cow calf operation should be a 63 day breeding season, 95% of the cows should be pregnant at 35 days after breeding, no more than 2% resorption/abortion in the cows diagnosed as pregnant, and delivery of a live, vigorous calf by 93% of the cows exposed to bulls. These goals are realistic and a herd's reproductive efficiency should be considered impaired when they are not met.

Definitions

The terms used in this discussion were defined in 1971 by a group working to standardize the descriptions of bovine reproductive failure. A clear understanding of the definitions is essential so that you and the veterinarian can work together to solve the problem.

Early embryonic death refers to deaths that occurs from the day of conception until about 42 days of gestation. This period of time is when the embryo is developing into a recognizable living animal we call a fetus. Losses occurring during this period of early development, and those that take place early in the fetal period, are usually not noticed. These early losses are usually considered to be infertile since it appears conception failed. The term abortion refers to the loss of a fetus from day 42 until about 260 days of pregnancy. A premature delivery describes a calf delivered from day 260 to the end of pregnancy. By common usage a dead calf expelled at term is a **stillbirth**. The phrase **born dead** is improper.

Death during the embryonic or early fetal period usually results in resorption or maceration (reddening, loss of skin, and loss of features during retention in the uterus). Death during the second trimester of pregnancy usually results in abortion or may be followed by the mummification of the calf. Rarely, the remains deteriorate and fill the uterus with pus, termed pyometra. A calf that dies during the late second or third trimester typically will be delivered in an advance state of decomposition termed **emphysema**. The delivery of an **emphysematous** fetus is often difficult and prolonged and is termed **dystocia**.

Diseases of the developing calf or of the placenta do not always result in fetal death. The calf may be born prematurely or at term and be weak and diseased. This is commonly described as the **weak calf syndrome**. Most of these calves will die. Some survive and may be chronically infected with the agent that caused the disease. The term describing such a calf is **persistently infected**.

Significance of Reproductive Failure

Mid-term or late abortion is of concern to any commercial, purebred, or backyard cow herd owner. The calf is lost and the barren female must be maintained for a long period of time or sold at a loss. The cow that experiences the loss of a developing embryo may conceive and carry a calf to term. However, the calving season is prolonged and the weaning weight of the calf will likely be reduced. It is important to remember that if the cause of the abortion or embryonic death is infectious, the disease threatens the rest of the herd. The persistently infected calf that survives also threatens the cow herd. It will usually shed the disease causing agent as long as it remains in the herd.

Reproductive failure has been found to be around 37% of all first breeding in which healthy cows and fertile bulls are used. Most of the losses happen in the first 45 days. Four percent of the cows that are pregnant 50 days after breeding will abort or deliver a dead calf prematurely. Five percent are stillbirths. Up to 28% of the stillborn will show some type of abnormal development (that is, .5 to 1 percent of all calves), 84% die because of a lack of oxygen, and 10% show signs of infection.

Because of many causes of reproductive failure in cattle, an incidence of 2 to 5 percent in a herd is common and expected if the area is free of brucellosis. When the incidence exceeds 5 percent owners should become concerned and seek a diagnosis.

Hereditary Causes of Reproductive Failure

A congenital defect in a developing fetus may cause abortion, premature birth, or stillbirth. However abortions associated with such defects may be caused by either hereditary or environmental factors. Abortions associated with genetic factors are beyond routine diagnostic capability except for those that occur near term and appear in a specific pattern in certain cattle breeds or bloodlines. Determining the cause of a single congenital defect, such as crooked leg disease, is complicated by the fact that such a defect can result from several genetic or environmental factors. Because of this, a rancher must be careful not to consider all congenital defects as hereditary.

In the past several years hereditary defects are rarely reported from diagnostic laboratories. This indicates that the breeders of purebred cattle are doing an effective job of eliminating genetic defects from the breeding stock.

Environmental Factors Causing Reproductive Failure

Mineral or vitamin deficiencies can be important factors in reproductive failure. Lesions typical of vitamin E and selenium deficiencies are identified in aborted fetuses. Vitamin A deficiency is associated with defective bone growth, birth of weak calves and abortion. Iodine deficiency may result in the birth of weak or dead, hairless, and goitrous calves. Energy and or protein deficiencies can cause infertility, usually associated with a failure to ovulate. Some researchers have concluded that protein malnutrition in late pregnancy may be associated with an excessive number of stillborn or weak calves.

There is some evidence to suggest that sudden changes in atmospheric temperature, either hot or cold, may cause cows to abort. Experimentally, this rarely occurs. Calves are aborted if a cow develops a high temperature as a result of infection rather than from a high environmental temperature. Direct trauma per rectum to the embryo or young fetus during pregnancy examination may cause death and resorption or abortion. It is a common misconception of ranchers and herdsmen that external injuries or trauma can readily cause abortion in cattle. External trauma due to trucking or handling in a chute, seldom results in abortion.

Certain plants and toxic chemicals are capable of causing abortion or congenital defects. Ranchers and veterinarians should become familiar with the plants that cause reproductive failure and take measures to control the plants or avoid grazing such plants during the times that the embryo or fetus are susceptible to damage by the toxic principles.

Infectious Factors Causing Reproductive Failure

This grouping lists the causes of reproductive failure associated with infectious diseases (Table 18). Detailed descriptions are limited to those diseases that are most prevalent in Great Basin cow herds. The proportion of abortions caused by infectious agents is not known. When the diagnostic laboratory does determine the cause, at least 90% are due to infection.

Infectious reproductive failure can be divided into four general classifications:

- Inflammation of specific organs caused by infectious agents.
- Debilitating disease that lowers efficiency of all the body systems.
- True venereal diseases transmitted by breeding.
- Infectious agents that specifically attack the reproductive system.

Infectious diseases of specific organs include an inflamed vagina or infection in the womb

(uterus). These conditions are caused by any number of agents that are commonly present in the reproductive tissues but only cause disease when predisposing conditions are presented. Inflammation of the uterus may vary from mild to severe enough to cause death. This condition, called metritis, usually occurs post-calving. Retained placenta, unsanitary assistance during calving, dirty calving quarters, and poor nutrition are among predisposing factors. Metritis may reduce fertility by preventing normal heat cycles. If cycling occurs, the inflammation can prevent conception or cause death of the embryo.

True Venereal Diseases

Trichomoniasis and Campylobacteriosis (Vibrio) are diseases transmitted during breeding. They are infectious diseases and are serious problems in Great Basin cow herds.

Trichomoniasis is caused by *Trichomonas foetus*, a protozoan organism that lives on the penis and prepuce of the bull. Infection occurs at breeding but does not prevent conception. It may persist in the uterus of the cow for up to 4 or 6 months causing an inflammation. The developing embryo will die 45 to 90 days after conception accounting for a 10% to 40% reduction in the subsequent calf crop. Some abortions do occur during the second and third trimester and those aborted calves should be sent to a diagnostic laboratory. The cow will develop an immunity, cycle, breed, and carry a calf to term. The immunity is short lived and the cow is susceptible to reinfection the next breeding season. A few cows are infected, carry a calf to term, and still shed the organism following calving. Bulls that are not infected at the beginning of the breeding season contract the disease when they breed an infected cow. Bulls four years old or older tend to become chronically infected with the organism. Control is now possible by use of a vaccine given before the breeding season plus following management practices that lowers the number of chronically infected cows and bulls.

Campylobacteriosis is a widespread cause of early embryonic death and infertility worldwide. Infection introduced into a non-infected or non-vaccinated herd will spread rapidly. Infection occurs at breeding time and the organism is spread by an infected bull. The organism causes early embryonic death; however, abortion can occur at any time, even during the third trimester. Symptoms are not observed but a rancher should suspect the disease if they observe an excessive number of repeat breeding females, a number of open cows, or a prolonged calving season. Campylobacteriosis can be prevented from causing reproductive failure by administration of a vaccine one month prior to the breeding season. The herd needs to be revaccinated yearly to maintain an effective level of immunity. The booster shots should be given just before the breeding season. The organism that causes this disease is Campylobacter fetus, formerly called Vibrio fetus venerealis.

Other Infectious Diseases

Brucellosis, Bangs disease, is caused by the bacterium Brucella abortus and is found in the placenta, the fetus, or the discharge of an infected cow. It is spread to susceptible cows by ingestion. Abortions, retained placenta, weak calves and infertility occur. Milk produced from an infected cow also harbors the organism. Man can become infected from drinking raw milk or coming in contact with the placenta, fetus, or vagina discharge of an infected cow. The disease in man is called undulant fever and is serious. Federal and state regulations have eradicated the disease in the Great Basin. There is still a threat and prevalence in the United States and foreign countries that prompts continued action.

Prevention of Bangs disease is accomplished by official calfhood vaccination of heifer calves. Vaccination must be done by an accredited veterinarian when the beef calves are 4 to 12 months

of age. In addition, all states have regulations stipulating pertinent health requirements necessary before cattle change ownership or move interstate. Ranchers should obtain an official health certificate that will be issued only after compliance with the Brucellosis test and vaccination requirements. Check with your local veterinarian to determine the requirements and for health certificates.

Leptospirosis is a bacterial organism that causes abortion two to five weeks after infection. Abortion is most common during the last trimester. At least five species affect cattle in the Great Basin. Leptospira pomona is the most common in cattle; however, the species icterohaemorrhagiae, grippotyphosa, hardjo and canicola also cause reproductive failure in cattle. The disease is prevalent in the Great Basin. The organism is shed in the urine of infected cattle, swine, horses, wildlife, rats, and mice. Susceptible animals are infected from ingesting a urine-contaminated feedstuff or drinking water. Chronically infected animals shed the organism in their urine for 2 to 10 months and in some cases longer. Leptospira species also infect man and causes swine herders disease. Vaccines are available for the five Leptospira species that affect cattle. Vaccination should be done 30 to 60 days before breeding and repeated yearly. Vaccination does not prevent infection, but it does control the reproductive failure caused by the organism.

Recent research indicates that the serotype of hardjo used in vaccines for years is not effective in cattle. Until this problem is solved ranchers should seek to determine the cause of all abortions and consult a veterinarian regarding vaccines and vaccination programs to prevent Leptospirosis.

Infectious Bovine Rhinotracheitis (IBR), or red nose is a herpes virus normally thought of as the cause of respiratory disease of cattle. However, in females the virus causes abortion. IBR also causes an inflammation of the vagina manifested as infertility. Diagnostic laboratories report that the IBR virus is a common cause of abortion in the Great Basin. The infection may cause abortion in 50% or more of the cows in a herd that contains susceptible females. Abortion occurs about 35 to 90 days after infection. Usually the cow will not be sick following infection. Calves aborted because of IBR usually are retained in the uterus 24-72 hours after death. Thus the fetuses are severely autolyzed. This is in contrast to a fetus that dies from foothill abortion and is expelled prior to autolysis. The IBR virus will often remain in the tissues of an animal following abortion or recover from red nose. This characteristic, called latency, means that recovered animals will shed the virus during times of stress for the remainder of their life. Thus, the latently infected animal serves as a source of virus for the rest of the cow herd or for other herds when marketed.

The only method of preventing IBR abortion is by vaccination. Some of the vaccines are live organisms and are not safe to use in pregnant animals. There are killed vaccines that are safe but require two injections the first year they are used. Research shows that yearly boosters of live or killed vaccines are necessary for an effective level of immunity to be maintained. Initial vaccination, and yearly boosters, should be given 30 to 60 days prior to the breeding season. Selling cows that abort will aid in control of herd IBR abortion problems by lowering the challenge imposed by the latently infected animals.

Bovine Virus Diarrhea Virus (BVDV) is commonly isolated from aborted fetus. The virus is widespread in Great Basin cow herds. Most females carry antibodies, indicating previous exposure to the BVDV agent. The number of BVDV abortions that happen when the infection is introduced into a herd depends on the number of susceptible cows, the stage of gestation of the cows in the herd, and the virulence of the virus.

Calves infected during the middle part of gestation usually die and are aborted. Calves infected

during the last third of gestation usually resist infection and are born normal, free of virus, and with antibodies to the virus. A complicating factor recently described shows that calves infected in the first 4 months of gestation may be born normal but will be persistently infected and free of antibodies. Many of these calves die the first year of their life but if they survive and reproduce their calves are born persistently infected. Persistently infected animals continuously shed vast numbers of viruses in their nasal, oral, and reproductive secretions. These animals serve as a continued reservoir of infection for cow herds and also to introduce the virus into other herds when marketed.

Calves aborted due to BVDV infection do not show characteristic lesions. However, calves with cerebellar hypoplasia, no hair, cataracts, and calves that are small and weak were likely infected in utero with the BVDV virus at a particular stage of fetal development.

Vaccination with a modified live or killed vaccine is recommended as a preventive measure. There are indications cows vaccinated with vaccines presently available are not always able to protect their fetuses from infection. There is more to be learned about the differences in the various strains of BVDV and methods of vaccination.

Conclusions

The reproductive failures discussed in this paper, and listed in Table 18, comprise the commonly recognized problems confronting the cattle industry today. Management decisions can help minimize losses from reproductive failure. Recognizing a problem exists and determining the cause will aid in making decisions concerning raising the immunity by use of vaccines and proper nutrition. Isolating sick animals, sanitation, disposal of carrier animals and persistently infected animals will aid in control of the problems by lowering the challenge. A local practicing veterinarian, by training and experience, is the best qualified person to advise the producer on livestock health problems.

REFERENCES

Anderson, K. J., D. G. LeFever, J. S. Brinks, and K. G. Odde. 1991. The use of reproductive tract scoring in beef heifers. Agri. Practice. 12:19.

Bellows, R. A. 1987. Physiological relationships that limit production of range beef cattle. In: Achieving Efficient Use of Rangeland Resources. Fort Keogh Research Symposium Proc. p 50.

Bellows, R. A., Gibson, R. B., Anderson, D. C., and Short, R. E. 1971. Precalving body size and pelvic area relationships in Hereford heifers. J. Anim. Sci. 33:455.

Bellows, R. A., D. J. Patterson, P. J. Burfening, and D. A. Phelps. 1987. Occurrence of neonatal and postnatal mortality in range beef cattle. II. Factors contributing to calf death. Theriogenology 28:573.

Bellows, R. A., O. O. Thomas, T. M. Riley, R. B. Gibson, N. F. Kieffer, J. J. Urick, and O. F. Pahnish. 1965. Feed effects on puberty in beef heifers. Proc. West. Sect. Amer. Soc. Anim. Sci. 23:23.

Bernard, C. S., M. H. Fahmy, and G. Lalande. 1973. The influence of age at first calving and winter feeding management as yearlings on calf production from Shorthorn beef cows. Anim. Prod. 17:53.

Beverly, J. R. , and J. C. Spitzer. 1979. Management of replacement heifers for a high reproductive and calving rate. Texas A&M Univ. B-1213 College Station, Texas.

Bolin, S. 1990. The current understanding about the pathogenesis and clinical forms of BVD. Vet. Med. 85:1124.

Bolze, R. P., and L. R. Corah. 1988. Effects of a single zeranol implant on conception rates and dystocia in primiparous beef heifers. Prof. Anim. Sci. 4:19.

Bond, J., and J. N. Wiltbank. 1970. Effect of energy and protein on estrus, conception rate, growth and milk production of beef females. J. Anim. Sci. 30:438.

Brown, L. N., K. G. Odde, D. G. Lefever, M. E. King, and C. J. Neubauer. 1988. Comparison of MGA-PGF2a to synchro-mate B for estrous synchronization in beef heifers. Theriogenology 30:1.

Burfening, P. J. 1979. Induction of puberty and subsequent reproductive performance. Theriogenology 12:215.

Byerley, D. J., R. B. Staigmiller, J. G. Berardinelli, and R. E. Short. 1987. Pregnancy rates of beef heifers bred either on puberal or third estrus. J. Anim. Sci. 65:645.

Chapman, H. D., J. M. Young, E. G. Morrison, and N. C. Edwards, Jr. 1978. Differences in lifetime productivity of Herefords calving first at 2 and 3 years of age. J. Anim. Sci. 46:1159.

Clanton, D. C., L. E. Jones, and M. E. England. 1983. Effect of rate and time of gain after weaning on the development of replacement beef heifers. J. Anim. Sci. 56:280.

Cohen, R. D. H., E. D. Jansen and H. H. Nicholson. 1987. Effect of repeated implantation with Zeranol from birth or weaning on growth and reproduction in beef heifers. Can. J. Anim. Sci. 67:37.p Corah, L. R. 1989a. Body condition- an indication of the nutritional status of beef cows. Agri-Practice 10:4, pg 25.

Corah, L. R. 1989. Low calf nutrition. Agri-Practice 10:27.

Corah, L. R. 1990. Estrus synchronization of heifers - MGA, a new (yet old) approach. Agri-Practice. 11:234.

Corah, L. R., 1991. Replacement Heifer Development. Proc., Amer. Assoc. of Bovine Pract. 23:81.

David, J. S. E., M. W. Bishop, and H. J. Cembrowicz. 1971. Reproductive expectancy and infertility in cattle. Vet. Rec. 89:181-185.

Deutscher, G. H. 1985. Using pelvic measurements to reduce dystocia in heifers. Mod-Vet-Pract. Santa Barbara Calif.; American Veterinary Pub. 66:751.

Deutscher, G. H. 1985. Developing Replacement Beef Heifers (Weaning - Breeding). Neb Guide - G80-493. Cooperative Extension, University of Nebraska, Lincoln.

Deutscher, G. H. 1991. Growing promoting implants on replacement heifers - A review. Pro. Range Beef Cow Symp. 12:169.

Deutscher, G. H., L. L. Zerfoss, and D. C. Clanton. 1986. Time of zeranol implantation on growth, reproduction and calving of beef heifers. J. Anim. Sci. 62:875.

Ferrell, C. L. 1982. Effects of postweaning rate of gain on onset of puberty and productive performance of heifers of different breeds. J. Anim. Sci. 55:1272.

Fox, D. G., C. J. Sniffen, and J. D. O'Connor. 1988. Adjusting nutrient requirements of beef cattle for animal and environmental variations. J. Anim. Sci. 66:1475.

Greer, R. C., R. W. Whitman, R. B. Staigmiller, and D. C. Anderson. 1983. Estimating the impact of management decisions on the occurrence of puberty in beef heifers. J. Anim. Sci. 56:30.

Gregory, K. E., D. B. Laster, L. V. Cundiff, R. M. Koch, and G. M. Smith. 1978. Heterosis and breed maternal and transmitted effects in beef cattle. II. Growth rate and puberty in females. J. Anim. Sci. 47:1042.

Gregory, K. E., D. B. Laster, L. V. Cundiff, G. M. Smith, and R. M. Koch. 1979. Characterization of biological types of cattle-Cycle III. II. Growth rate and puberty in females. J. Anim. Sci. 49:461.

Heitzman, R. J., D. J. Harwood, R. M. Kay, W. Little, C. B. Mallinson, and I. P. Reynolds. 1979. Effects of implanting prepuberal dairy heifers with anabolic steroids on hormonal status, puberty and parturition. J. Anim. Sci. 48:859.

Hixon, D. L., D. W. Moore, and D. W. Sanson 1994a. Synchronization of estrus in the postpartum beef cow comparing melengestrol acetate (MGA) with or without an accompanying prostaglandin (PGF2a) injection to the double injection PGF2a system. Proceedings West. Sec. Amer. Soc. Anim. Sci., 45:39-41.

Hixon, D. L., D. W. Sanson, and D. W. Moore. 1994b. Effects of growth-promoting implants on suckling calf performance and subsequent reproductive performance of replacement heifers. Proceedings West. Sec. Amer. Soc. Anim. Sci., 45:45-47.

Holloway, J. W., and R. Totusek. 1973. Relationships between preweaning nutritional management and subsequent performance of Angus and Hereford females through three calf crops. J. Anim. Sci. 37:807.

Johnson, S. K., G. H. Deutscher and A. Parkhurst. 1988. Relationship of pelvic structure, body measurement, pelvic area and calving difficulty. J. Anim. Sci. 66:1081. Kirkbride, C. A. 1977. Abortive diseases of cattle: Their significance and prevalence. Proc. Ann. Meeting Soc. for Theriog., St. Paul, MN 135-142; Vet. Med. Sm. An. Clin. 75, 8, pp 1151-1155.

Laster, D. B., H. A. Glimp, and K. E. Gregory. 1972. Age and weight at puberty and conception in different breeds and breed-crosses of beef heifers. J. Anim. Sci. 34:1031.p Laster, D. B., G. M. Smith, L. V. Cundiff, and K. E. Gregory. 1979. Characterization of biological types of cattle (cycle II). II. Postweaning growth and puberty of heifers. J. Anim. Sci. 48:500.

Laster, D. B., G. M. Smith, and K. E. Gregory. 1976. Characterization of biological types of cattle. IV. Postweaning growth and puberty of heifers. J. Anim. Sci. 43:63.

Lawrence, J. R., J. D. Allen, R. C. Herschler, and T. A. Miller. 1985. Synovex implants: Re-implantation and fertility in beef heifers. Agri-Practice 6:13.

LeFever, D. G., and K. G. Odde. 1986. Predicting reproductive performance in beef heifers by reproductive tract evaluation before breeding. CSU Beef Program Report, p. 13.

Lesmeister, J. L., P. J. Burfening, and R. L. Blackwell. 1973. Date of first calving in beef cows and subsequent calf production. J. Anim. Sci. 36:1.

Mickelsen, W. D. 1988. Evaluating reproductive efficiency in beef cattle herds. pp 155-159. Proc. Ann. Meeting AABP, West Lafayette, IN.

Mickelsen, W. D. 1990. Investigating the causes of low pregnancy rates in beef cattle herds. Vet. Med. 85:418.

Miller, R. B. 1982. A discussion on reproductive failure in cattle. Bov. Pract. 17, 39. Morrison, D. G., W. D. Williamson, and P. E. Humes. 1986. Estimates of heritabilities and correlations of traits associated with pelvic area in beef cattle. J. Anim. Sci. 63:432.

Odde, K. G. 1987. MGA and PGF2a for estrus synchromization. American Assoc,.of Bovine Prac., in Proceedings of 20th Annual Convention, Phoenix, AZ.

Odde, K. G. 1990. A review of synchronization of estrus in postpartum cattle. J. Anim. Sci. 68:817.

Odde, K. G., D. G. LeFever, and G. W. Boyd. 1989. Heifer and bull replacement for optimum production. Proceedings, Bull and Replacement Heifer Selection Workshops. CSU-Fort Collins.

Osburn, B. I., and P. C. Kennedy. 1981. Abortion, prenatal disease and fetal infections. pp 997-1003. In: J.L.

Howard (ed.) Current Veterinary Therapy, W. B. Saunders Co., Philadelphia.

Patterson, D. J. 1990. Control of the bovine estrous cycle with melengestrol acetate (MGA): Methods of synchronizing or inducing estrus. pp 25-41. Lexington, KY. In: Proc. Univ. of Kentucky Beef Cattle Roundup.

Patterson, D. J., R. A. Bellows, P. J. Burfening, and J. B. Carr. 1987. Occurrence of neonatal and postnatal mortality in range beef cattle. I. Calf loss incidence from birth to weaning, backward and breech presentations and effects of calf loss on subsequent pregnancy rate of dams. Theriogenology 28:557.

Patterson, D. J., L. R. Corah, and J. R. Brethour. 1990. Response of prepubertal Bos taurus and Bos indicus x Bos taurus heifers to melengestrol acetate with or without gonadotropin-releasing hormone. Theriogenology 33:661.

Patterson, D. J., L. R. Corah, J. R. Brethour, J. J. Higgins, G. H. Kiracofe, and J. S. Stevenson. 1992. Evaluation of reproductive traits in Bos taurus and Bos indicus crossbred heifers: Relationship of age at puberty to length of the postpartum interval to estrus. J. Anim. Sci. 70:1994.

Patterson, D. J., L. R. Corah, J. R. Brethour, M. F. Spire, J. J. Higgins, G. H. Kiracofe, J. S. Stevenson, and D. D. Simms. 1991. Evaluation of reproductive traits in Bos taurus and Bos indicus crossbred heifers: Effects of postweaning energy manipulation. J. Anim. Sci. 69:2349.

Patterson, D. J., L. R. Corah, G. H. Kiracofe, J. S. Stevenson, and J. R. Brethour. 1989a. Conception rate in Bos taurus and Bos indicus crossbred heifers after postweaning energy manipulation and synchronization of estrus with melengestrol acetate and fenprostalene. J. Anim. Sci. 67:1138.

Patterson, D. J., G. H. Kiracofe, J. S. Stevenson, and L. R. Corah. 1989b. Control of the bovine estrous cycle with melengestrol acetate (MGA): A review. J. Anim. Sci. 67:1895.

Patterson, D. J., R. C. Perry, G. R. Kiracofe, R. A. Bellows, R. B. Staigmiller, and L. R. Corah. 1992. Management considerations in heifer development and puberty. J. Anim. Sci. 70:4018.

Plugge, B. L., G. H. Deutscher, M. K. Nielsen, and S. K. Johnson. 1990. Melengestrol acetate (MGA) and prostaglandin for estrous induction and synchronization in prepuberal beef heifers. Prof. Anim. Sci. 6:24.

Rice, L. E. 1991. Nutrition and the Development of Replacement Heifers. Veterinary Clinics of North America: Food Anim. Practice. 7:27.

Richards, M. W., J. C., Spitzer, and M. B. Warner. 1986. Effect of varying levels of postpartum nutrition and body condition at calving on subsequent reproductive performance in beef cattle. J. Anim. Sci. 62:300.

Selk G. E., and K. S. Lusby. 1990. Management of beef cattle for efficient reproduction. Oklahoma State Univ. Coop. Ext. Ser. Circular E-869 p. 22.

Short, R. E., and R. A. Bellows. 1971. Relationships among weight gains, age at puberty and reproductive performance in heifers. J. Anim. Sci. 32:127.

Short, R. E., R. A. Bellows, J. B. Carr, R. B. Staigmiller, and R. D. Randel. 1976. Induced or synchronized puberty in heifers. J. Anim. Sci. 43:1254.

Staigmiller, R. B., R. A. Bellows, and R. E. Short. 1983. Growth and reproductive traits in beef heifers implanted with zeranol. J. Anim. Sci. 57:527.

Whitman, R. W., E. E. Remmenga, and J. N. Wiltbank. 1975. Weight change, condition and beef cow reproduction. J. Anim. Sci. 41:387.

Wiltbank, J. N., C. W. Kasson, and J. E. Ingalls. 1969. Puberty in crossbred and straightbred beef heifers on two levels of feed. J. Anim. Sci. 29:602.

Wiltbank, J. N., S. Roberts, J. Nix, and L. Rowden. 1985. Reproductive performance and profitability of heifers fed to weigh 272 or 318 kg at the start of the first breeding season. J. Anim. Sci. 60:25.

Wiltbank, J. N., W. W. Rowden, J. E. Ingalls, K. E. Gregory, and R. M. Koch. 1962. Effect of energy level on reproductive phenomena of mature Hereford cows. J. Anim. Sci. 21:219.

Zollinger, W. 1994. Palpation at 12 months of age. Personal Communication.