PEER REVIEWED

Improving Reproductive Efficiency Through the Use of Reproductive Tract Scoring in a Group of Beef Replacement Heifers

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Abstract

This study investigated the potential improvement in reproductive efficiency through reproductive tract scoring (RTS) of heifers 30-60 days prior to breeding. Between 2000 and 2004 the RTS of 1986 heifers (mean age of 395 days) were determined in two locations in Georgia as part of the Heifer Evaluation and Reproductive Development (HERD) project. These heifers were of similar age and were managed using comparable nutrition and management protocols. The Kaplan-Meier product-limit method was used to analyze the number of days from the start of the breeding period to conception for heifers with different RTS classifications. RTS was significantly associated with both time to conception and the proportion of heifers that conceived during the breeding period. The mean time to conception for heifers in the combined RTS 1 and 2 category (37.8 days) was significantly longer than for heifers with scores of 4 (19.7 days) or 5 (15.8 days), but not significantly different from heifers with RTS of 3 (29.2 days). The estimated percentages of heifers that would have conceived during a uniform 70 day breeding period were 94.6% of RTS 5, 91.2% of RTS 4, 87.6% of RTS 3, and 70.5% of RTS 1 and 2. This study indicates that reproductive tract scoring can be used to assist producers in the selection of heifers that will conceive at a higher rate and breed earlier in the breeding season.

Keywords: bovine, reproductive tract scoring, RTS, heifer, fertility

Résumé

Cette étude se penchait sur l'amélioration possible de l'efficacité reproductive suite à l'évaluation du tractus reproducteur de 30 à 60 jours avant la saillie chez des taures. Entre les années 2000 et 2004, le tractus reproducteur de 1986 taures (âge moyen de 395 jours) a été évalué à deux endroits en Georgie dans le cadre du programme d'évaluation et de développement reproducteur des taures (HERD). Ces taures avaient un âge similaire et leur régie était aussi similaire en termes de nutrition. L'analyse de survie de Kaplan-Meier a été utilisée pour examiner le nombre de jours nécessaires pour concevoir depuis le début de la période de reproduction chez des taures ayant des scores différents au niveau du tractus reproducteur. Le score du tractus reproducteur était significativement associé avec le temps nécessaire pour concevoir et aussi avec la proportion de taures qui concevaient durant la période de reproduction. Le temps moyen avant la conception chez les taures avec des scores du tractus reproducteur dans les catégories 1 et 2 combinées (37.8 jours) était significativement plus long que le temps avant la conception chez les taures avec des scores de 4 (19.7 jours) ou de 5 (15.8 jours) mais n'était pas différent du temps avant la conception chez les taures avec un score de 3 (29.2 jours). Le pourcentage estimé de taures qui concevraient durant une période uniforme de 70 jours était de 94.6% chez les taures avec un score du tractus reproducteur de 5, de 91.2% chez les taures avec un score de 4, de 87.6% chez les taures avec un score de 3 et de 70.5% chez les taures avec un score combiné de 1 et de 2. Cette étude indique que l'évaluation du tractus reproducteur peut être utilisée pour aider les producteurs à sélectionner les taures qui vont concevoir avec un taux plus élevé et se reproduire plus tôt dans la saison de reproduction.

Introduction

This study investigated the value of performing reproductive tract scoring (RTS) of beef heifers 30-60 days prior to breeding. The objective of examining the reproductive tract of beef heifers is to improve herd re-

productive efficiency, which is key to the economic well-being of a cow/calf enterprise.[14] Cattle that conceive early in the breeding season each year are more profitable.[2] Since reproduction is not highly heritable,[3,13] management and selection tools are used to improve herd reproductive efficiency,[2] a major factor in herd profitability.[6] Heifers that reach puberty early and conceive early in the breeding season have increased lifetime profitability.[12]

Puberty is defined as expression of estrus behavior and ovulation of a fertile oocyte.[15] Three main factors that determine puberty in beef heifers are age, nutrition and genetics.[9,15] Age variation within the contemporary group is impacted by the length of the contemporary calving season. Nutritional state of the heifers can be assessed within a contemporary group by weight gain, body condition score and target weight.[9,10,20] Nutrition of the heifers should be adequate to attain a target weight of 65% of their mature weight at breeding.[7,8,9,20,21] Following selection by age and target weight, the remaining criteria for reproductive efficiency has some genetic base and can be estimated by palpation of the reproductive tract.[1] In a contemporary group of heifers that are of similar age, well fed and managed as a group, the onset of puberty may vary due to genetic variation and/or potential reproductive efficiency.[1,9,12] This variation in age at puberty can be assessed by the attending veterinarian using reproductive tract scoring (RTS) to estimate the pubertal status of a heifer.[1] Reproductive tract scoring has been validated as a method to identify and select heifers within a contemporary group for reproductive efficiency.[1,16,18]

RTS ranges from one to five based on size, tone and structure of reproductive tract organs with one being immature and five being mature[1] (Table 1). Heifers that have lower RTS generally conceive later and fewer heifers will become pregnant during a defined breeding season.[1,16,18] The objective of this study was to evaluate RTS to predict the number of days to conception and the proportion of beef heifers that fail to conceive during a 60-70 day breeding period.

Materials and Methods

RTS of 1986 beef heifers from two locations in Georgia during the years 2000-2004 were determined 30 to 60 days prior to breeding. At the time of examination, the heifers had a mean age of 395 days. The heifers had been weaned and managed using similar nutrition and management protocols. The reproductive tract scoring system utilized in this study was developed by Anderson *et al* in 1987 (Table 1).[1] Heifers at both locations during 2000 and 2001 were synchronized by feeding melengestrol acetate[a] at 0.5 mg per head per day for 14 days. Nineteen days after removal of the melengestrol acetate, an injection of prostaglandin[b] was administered as per label, and the heifers were bred by artificial insemination (AI) 12 hours after visual observation of estrus.[4] After AI the heifers were bred by natural service, with a total breeding season ranging from 60 to 70 days.

Heifers at both locations in 2002, 2003 and 2004 were synchronized with a progesterone impregnated vaginal insert;[c] seven days after insertion an injection of prostaglandin[b] was administered and the vaginal insert was removed. Heifers were bred by AI 12 hours after visual observation of estrus. After AI breeding the heifers were placed with a bull and bred by natural service, with a total breeding season ranging from 60 to 70 days. Pregnancy was determined initially by ultrasound post-AI, and a second pregnancy examination using ultrasound and/or palpation estimated when heifers were bull bred and if the AI pregnancy was maintained.

A computerized estrus detection system[d] was used at only one of the locations from 2000 through 2004. Transmitters were placed on the heifers at the time of prostaglandin injection and removed at the first pregnancy examination.

Pearson Chi-square testing was used to compare the proportion of heifers identified as pregnant following the breeding season among different categories of RTS, age, year of the project and location. The Kaplan-Meier product-limit method was used to analyze the number of days from the start of the breeding period to

Table 1. Description of reproductive tract scores.[1]

Reproductive Tract Score	Uterine horn[†]				Ovaries
	Approx diameter (mm)	length	height	width	Ovarian structures
1 Immature - no tone	<20	15	10	8	no palpable follicle
2 No tone	20-25	18	12	10	8mm follicles
3 Slight tone	25-30	22	15	10	8-10mm follicles
4 Good tone	30	30	16	12	>10mm follicles, CL possible
5 Good tone erect	>30	>32	20	15	>10mm follicles, CL present

[†]Measurements reported in millimeters (mm)

conception. Although synchronization was performed using two different protocols, both utilized an injection of PGF-2a, which was considered the start of the breeding period. Heifers that displayed estrus during the synchronization protocol, but before prostaglandin injections were administered, were inseminated without receiving PGF-2a. Heifers that conceived to an early insemination were arbitrarily assigned a number of days to conception of 0.5. In Kaplan-Meier analysis, subjects may either experience the event of interest (i.e., conception) or they are 'censored' when 1) lost to follow-up, 2) removed from the study for a reason unrelated to the event of interest, or 3) the study ends before the event of interest has occurred. This approach explicitly allows animals that are censored to contribute to the time at risk for as long as they are in the study, without making assumptions about what would have occurred had they remained for a longer period of time. In this study, heifers that were identified as non-pregnant at the time of the final pregnancy examination were censored on the last day of the breeding period. The log-rank test was used to compare the overall equality of RTS survivor functions, and follow-up pairwise comparisons were conducted using a Bonferroni-corrected log-rank test to limit the experiment-wise Type-I error rate to 5%. Restricted mean survival times were obtained as the area under Kaplan-Meier survivor curves. Analysis was performed using commercially available statistical software,[e] and *P*-values < 0.05 were considered statistically significant.

Results

Reproductive tract scores (RTS), age and the number of days to conception following an estrus synchronization protocol were evaluated for 1,986 heifers enrolled in the Heifer Evaluation and Reproductive Development (HERD) project at two Georgia locations during the years 2000-2004. Heifers determined to be pregnant at the time of initial evaluation were removed from the program and not included in the analysis. The distribution of heifers by RTS, age, location and year are shown in Table 2, along with the proportion of heifers that were ultimately identified as pregnant. Since a RTS of 1 was only observed in 2 (0.1%) heifers, scores for heifers with a RTS of 1 or 2 were combined in the analysis. Of the variables that were evaluated, only RTS was significantly associated with the proportion of heifers that were identified as pregnant following a 60-70 day breeding period. Synchronization protocols varied by year, with melengestrol acetate being used in 2000-2001 and progesterone impregnated vaginal inserts being used in 2002-2004, but the proportion of pregnant heifers did not differ significantly between protocols (88.9% for melengestrol acetate vs. 88.0% for progesterone impreg-

Table 2. Distribution and pregnancy outcome of 1,986 heifers enrolled in a Georgia beef heifer development project by reproductive tract score (RTS), age, location and project year.

Variable	Category	†No. heifers (% pregnant)	‡*P*-value
RTS	1 & 2	56 (66.1)	< 0.001
	3	295 (82.7)	
	4	1,260 (89.3)	
	5	375 (93.1)	
Age (days) at the beginning of the breeding period	364 – 392	251 (85.3)	0.139
	393 – 420	763 (87.8)	
	427 – 448	709 (88.9)	
	449 – 483	263 (91.6)	
Location	Calhoun	963 (88.4)	0.999
	Irwin	1,023 (88.4)	
Project year	2000	425 (90.1)	0.485
	2001	392 (87.5)	
	2002	460 (89.6)	
	2003	389 (87.1)	
	2004	320 (86.9)	
Total		1,986 (88.4)	

†No. heifers (% pregnant) - number of heifers in each category and the percentage that were identified as pregnant following a 60-70 day breeding period.
‡*P*-value - Chi-square homogeneity test for the proportion of pregnant heifers.

nated vaginal inserts, Chi-square = 0.328, 1df, P=0.567).

Time to conception was evaluated for heifers with different RTS classifications by using the Kaplan-Meier method (Figure 1). A log-rank test for equality of survivor functions was highly significant (Chi-square = 64.0, 1df, P<0.001), with higher RTS classifications corresponding to shorter times to conception. In follow-up pairwise comparisons, the time to conception for heifers in the combined RTS 1 and 2 categories was significantly longer than for heifers with scores of 4 or 5, but was not significantly different from the heifers with a RTS of 3. Days to conception using survivor functions for heifers with an RTS of 3, 4, or 5 were all significantly different from one another (Table 3). Compared to heifers with a RTS of 5, the mean time to conception was 3.9 days longer for heifers with RTS 4, 13.4 days longer for RTS 3 and 22 days longer for RTS 1 or 2. The estimated percentages of heifers that would have conceived during a uniform 70 day breeding period were 94.6% of RTS 5 heifers, 91.2% of RTS 4, 87.6% of RTS 3 and 70.5% of those with RTS 1 and 2. These estimates are slightly higher than the actual pregnancy percentages (Table 2) because they are adjusted for variation in the length of the breeding period, which ranged from 60-70 days.

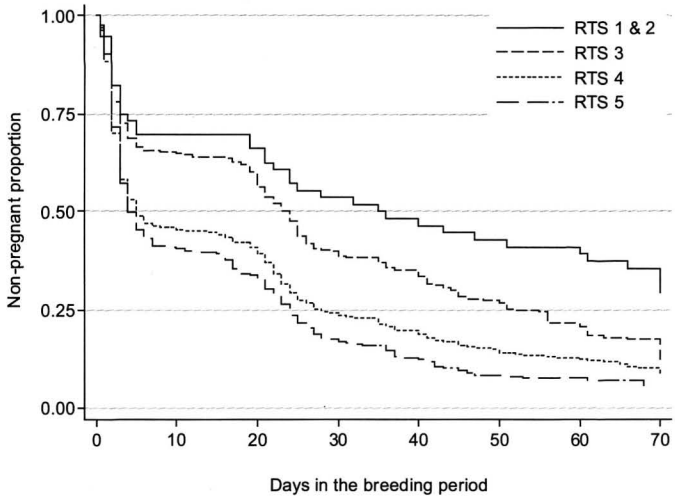

Figure 1. Kaplan-Meier survival curves representing time to conception by reproductive tract score (RTS) for 1,986 heifers enrolled in a Georgia beef heifer development project during 2000-2004.

Discussion

It has been suggested that the largest single potential income improvement in the beef cattle industry is in the area of reproductive efficiency.[14,19] Likewise, an estimate of the total cost of reproductive failure and reproductive disease in the beef industry was about $500 million.[2] The selection and management of replacement heifers can positively influence the reproductive efficiency of the beef cattle industry.[15] Heifers managed to calve as two-year-olds have a higher lifetime productivity than heifers that calve as three-year-olds.[6,12]

Reproductive losses or gains in a herd are dependent on both the number of females that become pregnant during the breeding season, and the date they become pregnant within the breeding season. The normal calf weight of 2.5 lb (1.14 kg) per day of age means that for each 21-day delay in breeding, a cow weans a calf that is 52.5 lb (23.9 kg) lighter.[11,14,17] To improve the odds of a cow conceiving early in the breeding season she must calve early as a heifer.[15] It is extremely difficult to step-up breeding dates for a young cow from year to year, so if a first calf heifer calves late she is likely to be reproductively inefficient for the remainder of her reproductive life.[12] In order for a heifer to conceive early in the breeding season, she must reach puberty early.[15] Heifers bred on their third cycle post-puberty compared to their first cycle have a 23% improvement in preg-

Table 3. Mean and median number of days to conception along with the non-pregnant percentage (95% confidence intervals) by reproductive tract score (RTS) for heifers enrolled in a Georgia beef heifer development project during 2000-2004.

RTS Category	No. heifers	†Mean (95% CI)	Median (95% CI)	‡Non-pregnant % (95% CI)
1 & 2	56	37.8[a] (30.2, 45.3)	35 (21, 61)	29.5 (15.8, 44.6)
3	295	29.2[a] (26.3, 32.1)	24 (21, 25)	12.4 (7.7, 18.2)
4	1,260	19.7[b] (18.4, 20.9)	5 (5, 6)	8.8 (7.0, 10.8)
5	375	15.8[c] (13.8, 17.8)	4 (4, 6)	5.4 (3.0, 8.8)
Total	1,986	20.9 (19.8, 21.9)	6 (5, 11)	9.1 (7.6, 10.9)

†Mean - survivor functions with a superscript in common are not significantly different when using a Bonferroni-corrected log-rank test to control the error rate at 5% over all comparisons.
‡Non-pregnant % - Kaplan-Meier estimate of the percentage of heifers expected to remain non-pregnant following a uniform 70 day breeding period.

nancy rate.[5] If heifers are bred to calve 30 days before the adult cows and conceive at a greater rate on the third heat cycle,[5] then heifers that reach puberty at 11 to 13 months of age are desirable. This is calculated by breeding heifers to calve one month before the cows so they will calve at 23 months (730 days) minus the gestation length of 282 days, minus three heat cycles (63 days), to total 385 days.

RTS determines pubertal status by rectal palpation of the size and tone of the uterus, and size and structures on the ovaries within a contemporary group of heifers at 30 to 60 days before breeding.[1] Generally, a score of four or five indicates the heifer has reached puberty, a score of three is slightly pre-pubertal, a score of two is immature and a score of one is very immature.[1] Experience with the technique increases the predictive ability of the likelihood of heifers to breed early in the breeding season.[16,18] The combination of a decreased rate of pregnancy and a later date of conception for the lower RTS is an indication of a lower income potential for heifers with a lower RTS. Heifers with a RTS below 3 represent a potential economic loss in heifer development costs. The potential economic impact of poor reproduction efficiency could be reduced by removing those heifers that are less likely to conceive early in the breeding season by examining the reproductive tract 30-60 days prior to breeding. Additionally, if this decreased potential income is identified 30-60 days before exposure to a bull or AI, cattlemen could alter nutrition and management to improve pregnancy rates or eliminate heifers with lower RTS from the breeding pool.[10] If reproductively inefficient heifers can be identified early, a producer may decide to sell them as open heifers before incurring the expense of heifer development and attempted breeding.

Conclusions

Reproductive tract scoring prior to breeding was found to be a good predictor of which animals were more likely to conceive in a 70 day breeding season, therefore it may be a valuable management procedure for beef production units. Practitioners can identify heifers that are unlikely to breed early in the breeding season. This information can be used by cattlemen to market potentially reproductively inefficient heifers before incurring the increased cost of developing the heifers as a replacement. Additionally, the outcome of the nutritional program during the growing period can be evaluated before the breeding season begins. The end result will be the selection of heifers that breed earlier in the breeding season, wean heavier calves and are more likely to breed back with their second calf earlier in future breeding seasons. RTS allows resources to be reserved for individual animals that are more likely to be successful breeding animals.

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Endnotes

[a] MGA, Pfizer Animal Health, Exton, PA
[b] Lutalyse, Pfizer Animal Health, Exton, PA
[c] EAZI-BREED™ CIDR®, Pfizer Animal Health, Exton, PA
[d] HeatWatch®, DDx, Inc. Denver, CO
[e] Stata version 9.0, StataCorp LP, College Station, TX

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Abstracts

A Novel Approach to the Treatment of Sub-Clinical Intramammary Infection in UK Dairy Cows: Preliminary Findings from a Recent Research Project

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151 sub-clinically infected quarters were selected to receive either an intramammary antibiotic twice a day for seven days, or one of two treatment regimes that required the gland to not be milked for seven days with antibiotic administered only once. The bacteriological cure rates were not significantly different between the treatment groups, nor were the proportion of quarters with a somatic cell count below either 100,000 or 200,000 cells per ml 21 and 28 days after treatment was initiated. The mean of the log transformed quarter somatic cell cow counts were not significantly different between treatment groups 14 days after treatment initiation. This study showed that there was a better than expected cure rate of subclinical intramammary infection when a "simulated dry period" is used in conjunction with antibiotic therapy.

Quarter and Cow-Level Risk Factors for Clinical Mastitis and Elevated Somatic Cell Count in Dairy Cows: A Review and Preliminary Findings from a Recent UK Research Project

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Individual quarter and cow-level risk factors for the development of clinical mastitis (CM) and elevated somatic cell count (SCC) are reviewed and a recent U.K. study attempting to quantify these factors in described. Observations including body condition score (BCS), udder and leg hygiene scores (UHS, LHS), hyperkeratosis of the teat-end (teat-end callosity or TEC), milking order and milking position were collected form eight commercial south-west dairy farms, totaling 1677 cows over a 12-month period. Cases of CM were recorded by the farmers and herdpersons using a pre-defined format and samples were requested from all cases using equipment and a Standard Operating Procedure (SOP) provided. A total of 53,364 teat-end scores, 29,282 hygiene scores and 14,074 body condition scores were available for analysis. Bacteriological analysis from 829 clinical mastitis cases were a sample was made available revealed *Escherichia coli* to be the most prevalent pathogen (219 isolated, 26.4%) and *Streptococcus uberis* to be the second-most prevalent pathogen (162 isolated, 19.5%). *S. uberis* was most commonly isolated from 240 sub-clinical mastitis samples (31 isolated, 12.9%).