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Ultrasonographic reproductive tract measures and pelvis measures as predictors of pregnancy failure and anestrus in restricted bred beef heifers

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ABSTRACT

Previous reports have shown that reproductive tract score (RTS) can predict reproduction outcomes in seasonally bred beef heifers, although the accuracy can vary. Some ultrasonographic measures of the female reproductive tract and pelvis area have also been associated with reproductive outcome in young heifers. The objectives of this study were to determine which transrectal ultrasound or pelvis measures taken at a single examination are independent predictors of reproductive failure and whether the RTS system can be optimized with this information. In this observational study, year-old beef heifers (n = 488) in 2 birth cohorts were followed from just before the first breeding until confirmation of pregnancy. A single pre-breeding examination included body condition score, RTS, ultrasound measures of the reproductive tract (length and diameter of the left and right ovaries, presence and diameter of a CL, largest follicle diameter and left uterus horn diameter) and transverse and vertical diameters of the pelvis. Additional farm records including dam parity, sire, birth weight and birth date, weaning weight, weaning date, prebreeding body weight, AI dates, and semen used were available. Breeding consisted of 50 days of AI, followed 5 to 7 days later by a 42-day bull breeding period. Pregnancy failure was defined as the failure to become pregnant after the AI and bull breeding periods, while anestrus was defined as the failure to be detected in estrus during the 50-day AI period. From the prebreeding data and farm records, independent predictors of pregnancy failure and anestrus were identified using stepwise reduction in multiple logistic regression models. Age at the onset of breeding was the only consistent independent predictor of pregnancy failure and anestrus in both cohorts of this study ($P < 0.05$). Body condition score, uterus horn diameter, absence of a CL, largest follicle of less than 13 mm, and pelvis area (PA) were the prebreeding examination variables that remained in prognostic models ($P < 0.1$). Combining either the model based on the 3 remaining ultrasound measures or RTS with PA provided more accurate prognostic models for pregnancy failure and anestrus than using RTS alone ($P < 0.05$). It is concluded that ultrasound measures have prognostic value for pregnancy failure in restricted bred yearling heifers as a result of their association with anestrus, and that smaller PA has additional prognostic value for poorly performing heifers.

1. Introduction

The ability to select young heifers that will reproduce effectively in a seasonal breeding system has advantages over the alternative approach of waiting until reproductive

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failure occurs [1,2]. Reproductive tract score (RTS) predicts anestrus and pregnancy failure in heifers independently of age, body weight (BW), and body condition score (BCS) and is a valid selection tool to enhance reproductive performance of herds [3–7]. However, estrus cycle stage and proportion of heifers in anestrus affect the accuracy of RTS, the complexity of the RTS system affects its repeatability, and other tests with potential to improve RTS are available [5,7–9].

The ultrasonographic presence of a CL has been used to mark the onset of puberty, has substantial repeatability, is more accurate than blood progesterone determination, and is a predictor of reproductive outcome in seasonally bred cows and heifers [9–12]. Ovary size is associated with antral follicle count (AFC), which in turn is associated with follicular reserve and fertility, whereas AFC is not affected by estrus cycle stage [13,14]. Maximum follicle diameter is correlated with uterus, cervix, and vaginal diameter and increases in the 10 weeks before first ovulation in heifers because of increased LH pulse frequency [13,15–19]. Larger PA has been associated with early onset of puberty in heifers and improved libido in bulls [20–22].

The objective of this study was to determine which individual transrectal ultrasound or pelvis measures taken at one point in time before breeding are independent predictors of reproductive failure in seasonally bred beef heifers and whether this knowledge can be used to optimize RTS.

2. Materials and methods

This was an observational study of 488 uniquely identified Bovelder beef heifers born in either 2007 (n = 259) or 2008 (n = 229) (2007 and 2008 cohorts) that were followed from just before their first breeding season to confirmation of pregnancy. The farming system, breed, and location have been described previously [5,7,20,23–25]. Farm data collected included the following: birth weight and birth date, parity of dam, sire, bull allocated, and first to fourth AI day numbered from the mating start date (MSD).

Heifers were weighed either 22 days (2007 cohort) or 27 or 24 days (2008 cohort) before the MSD (prebreeding BW), and a single prebreeding examination was performed 7 days (2007 cohort) or 27 or 24 days (2008 cohort) before the MSD. During the prebreeding examination, heifers were restrained individually in a chute, and the following data were collected in the same order by one experienced veterinarian: First, BCS was determined using a 9-point scale [26]. This was followed by RTS by transrectal palpation using a 5-point scale [3], then followed by transrectal ultrasonographic measurements of the reproductive tract [27], using a real-time digital ultrasound imaging system set in B-mode with a variable frequency linear probe set at 5 MHz (SIUI CTS-900V; Shantou Institute of Ultrasonic Instruments, Shantou, China). The interpolar length of the left and right ovaries, the diameter of the left and right ovaries at the deepest point (2008 cohort only), the presence and diameter of a CL, the diameter of the largest follicle, and diameter of the left uterus horn near the base (UD) were recorded. Finally, internal vertical diameter (VD) and transverse diameter (TD) of the pelvis were measured by transrectal placement of a caliper type pelvimeter (Rice pelvimeter; Lane Manufacturing, Denver, Colorado) [20,28,29]. Farm management and staff were blinded to all the measured prebreeding data throughout the trial, except for the prebreeding BW.

The MSD was October 15 of each year, and breeding consisted of 50 days of continuous estrus observation by visual inspection, and once daily AI of all heifers identified in estrus during the preceding 24 hours by the same inseminator. Five to 7 days after each 50-day AI season, all heifers were joined with bulls in a single multisire group at a heifer:bull ratio of 30-35:1 for 42 days. Pregnancy diagnoses were performed by transrectal palpation 138 or 165 days after MSD (2007 and 2008 cohorts, respectively).

For the purpose of regression models, BCS was categorized into 2 categories (<6 and ≥ 6) and RTS into 3 categories (1–2, 3, and 4–5) [30]. Diameter of the largest follicle was used either as a continuous variable or was dichotomized using various cutoffs (7, 8, 9, 12, 13, and 14 mm). Pelvis area (PA) was calculated as the product of the TD and VD, and rescaled values of PA (RPA) and uterus diameter (RUD) were calculated within birth cohort using the following formula:

$$X^{*} = (X - X_{minimum}) \div (X_{maximum} - X_{minimum})$$

where X* = RPA or RUD and X = PA or UD.

If a heifer was not detected in estrus, it was assumed that she remained prepubertal until the end of the 50-day AI season and was defined as anestrus, whereas pregnancy failure was defined as a negative pregnancy test at the end of the AI and bull breeding periods.

Correlations were estimated using Spearman correlation for non-normally distributed data (only age in this study) and Pearson correlation for normally distributed data. Independent proportions were compared using the Fisher exact test, and means and medians were compared using analysis of variance with the Tukey–Kramer multiple comparison test and the Kruskal–Wallis one-way analysis of variance, respectively.

Multiple linear regression models (for length of the longest ovary, diameter of the largest follicle, UD, and PA) and logistic regression models (for absence of a CL, absence of a follicle $\geq$13 mm, anestrus, and pregnancy failure) were constructed using a backward elimination process [31] with $P < 0.20$ for initial inclusion and $P_{Wald} < 0.10$ for retention in models. Predictors that were considered included year of birth, dam parity (1, 2, or $\geq$3), prebreeding BW (kg), growth rate (kg/day), age at onset of breeding (days) and BCS category at examination, presence or diameter (mm) of the CL, diameter (mm) of the largest follicle or presence of a follicle of at least 7, 8, 9, 12, 13, or 14 mm, RUD, RPA, length of the longest or shortest ovary (mm) or combined length of the 2 ovaries (mm), or ovary length difference (mm). Once only independent variables remained in each model ($P_{Wald} < 0.10$), each of the eliminated variables was included individually again to test for confounding. Confounding was considered if inclusion of a variable changed the coefficient of one of the independent predictors by more than 15%.

Finally, independent prebreeding examination predictors of anestrus and pregnancy failure were combined