PHENOTYPIC DATA COLLECTION FOR REPRODUCTIVE TRAITS IN REPLACEMENT BEEF HEIFERS

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BACKGROUND. Heifers that calve early during their first calving season have higher lifetime calf production than those that calve late (Lesmeister et al., 1973; Perry and Cushman, 2013). Because most calves are weaned at a particular time rather than on a weight-constant or age-constant basis, calves born late in the normal calving season are usually lighter than those born early. This tends to decrease the total lifetime productivity of their dams (Lesmeister et al., 1973). Furthermore, cows that calve late one year tend to calve late or fail to calve the subsequent year (Burris and Priode, 1958). Therefore the age at which a heifer reaches puberty is highly correlated to the date at which conception occurs, and conception date during a heifer's first breeding period is correlated to lifetime fertility and reproductive longevity. Improvements in procedures to assess the reproductive status of beef heifers prior to their first breeding period creates the opportunity to standardize procedures for phenotypic data collection among heifers selected as future herd replacements and utilization of more predictive indicator traits in national cattle evaluations of heifer pregnancy. This document provides an overview of the procedures that warrant consideration for evaluation of heifers prior to their first breeding period and suggestions for phenotypic data collection and reporting criteria for specific reproductive traits.

PREBREEDING EVALUATION. A prebreeding evaluation is recommended for all yearling-age heifers, and should include: animal identification, weight, pelvic area measurement and reproductive tract score. It is strongly encouraged that prebreeding exams be performed four to six weeks prior to breeding.

Reproductive tract scores. The reproductive tract scoring system (RTS, Table 1; Anderson et al., 1991) was developed to assist beef producers with selection of potential herd replacements and support timing of estrous synchronization programs (Patterson et al., 2013a). The reproductive tract scoring system is used to estimate pubertal status. Scores are subjective estimates of sexual maturity, based on ovarian follicular development and palpable size of the uterus. A RTS of 1 is assigned to heifers with infantile tracts, as indicated by small, toneless uterine horns and small ovaries devoid of significant structures. Heifers scored with a RTS of 1 are likely the furthest from puberty at the time of examination. Heifers assigned a RTS of 2 are thought to be closer to puberty than those scoring 1, due primarily to larger uterine horns and ovaries. Those heifers assigned a RTS of 3 are thought to be on the verge of estrous cyclicity based on uterine tone and palpable follicles. Heifers assigned a score of 4 are considered to be estrous cycling as indicated by uterine tone and size, coiling of the uterine horns, as well as presence of a preovulatory size follicle. Heifers assigned a score of 4 do not have an easily distinguished corpus luteum. Heifers with RTS of 5 are similar to those scoring 4, except for the presence of a palpable corpus luteum. Prebreeding examinations that include RTS furnish the opportunity to assess reproductive development, but further provide an appraisal of possible aberrant situations (freemartins, pregnancy, cystic conditions) that may detract from a heifer's subsequent reproductive potential (Patterson et al. 1999; Lamb, 2013; Patterson et al., 2013b).

Table 1. Reproductive tract scores (RTS; Anderson et al., 1991)

RTS	Reproductive status	Uterine horns	Ovarian length (mm)	Ovarian height (mm)	Ovarian width (mm)	Ovarian structures
1	Prepubertal, infantile tract	Immature, < 20 mm diameter, no tone	15	10	8	No palpable follicles
2	Prepubertal, > 30 days to puberty onset	20-25 mm diameter, no tone	18	12	10	8 mm follicles
3	Peripubertal, < 30 days to puberty onset	20-25 mm diameter, slight tone	22	15	10	8-10 mm follicles
4	Pubertal, follicular phase	30 mm diameter, good tone	30	16	12	10 mm follicles, CL possible
5	Pubertal, luteal phase	> 30 mm diameter	>32	20	15	CL present

Reproductive tract scoring is a repeatable (between and within veterinarians) and accurate (sensitivity = 82% and specificity = 69%) measure of pubertal status in heifers (Rosenkrans and Hardin, 2003). Holm et al. (2009), Pence et al. (2007), and Pence and BreDahl (1998) concluded that RTS is a predictor of heifer fertility, compares well with other traits used as predictors of production outcomes, and is likely to be a good predictor of lifetime production of the cow. Recently, RTS has been found to correlate with AI pregnancy rate following fixed-time AI (Thomas et al., 2013). But, RTS has not yet been implemented in national cattle evaluations. Figure 1 represents a modified interpretation of the conceptual model for puberty onset in the heifer presented by Day and Anderson (1998). This model combines the associated endocrine and ovarian changes that occur as heifers approach puberty, in addition to the corresponding RTS that would be assigned at respective points in development. A RTS of 1 corresponds to the point in time at which the pattern of luteinizing hormone (LH) release is characterized by low-frequency, high amplitude pulses. This is due to the fact that the hypothalamic-pituitary axis is highly responsive to negative feedback from estradiol. Reproductive tract scores of 2 and 3 are associated with the pre- and peri-pubertal phase, at which time responsiveness to estradiol negative feedback begins to decrease, causing increases in LH pulse frequency, follicular growth, and estradiol secretion. The decline in estradiol negative feedback and increase in LH secretion result in significant increases in follicular growth, and elevated concentrations of estradiol sufficient to induce estrus and the preovulatory LH surge. Reproductive tract scores of 4 and 5 are assigned to heifers that have reached puberty, but differ in stage of the estrous cycle at the time of the prebreeding exam (follicular phase = 4; luteal phase = 5).

While RTS can be effectively used in phenotypic selection to cull heifers that are abnormally delayed in achieving puberty, its greatest value would be inclusion into national cattle evaluations. This could be accomplished by developing heifer puberty EPDs that could be used in economic selection indexes, or as indicators of reproductive success in heifer pregnancy, sustained reproductive success, or stayability EPDs. Further research is needed in this area.

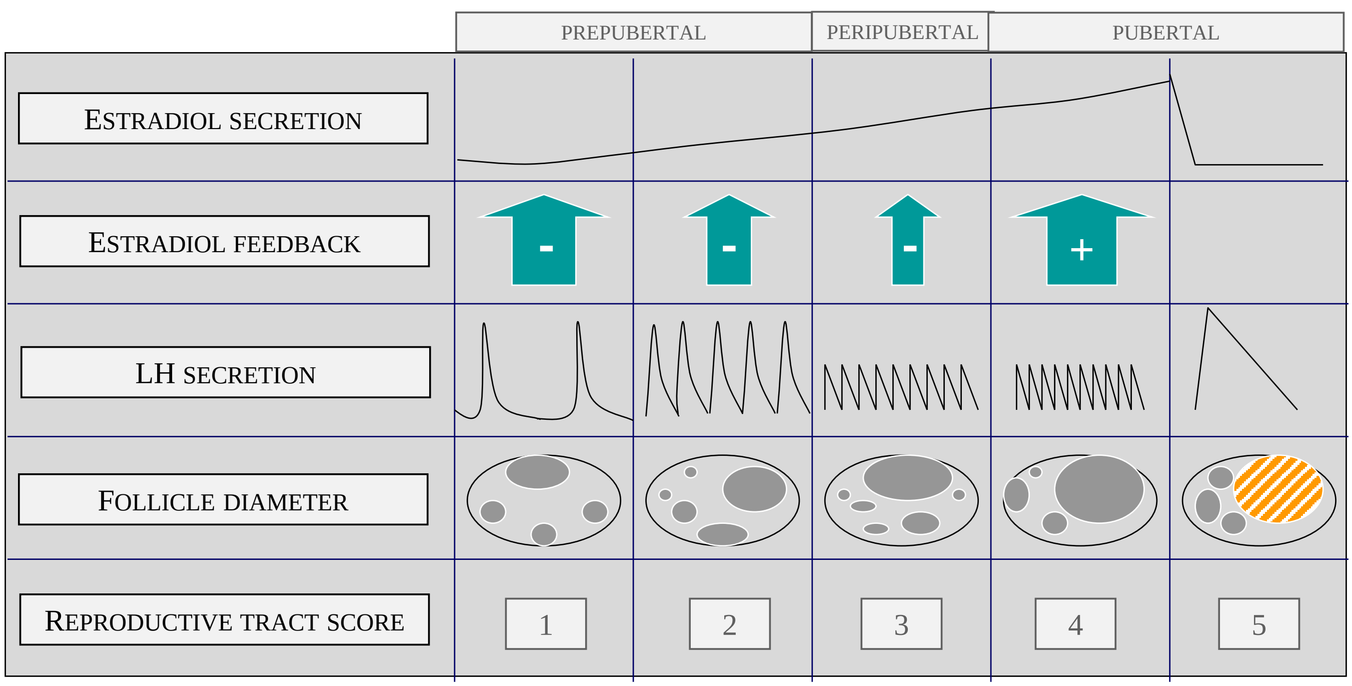
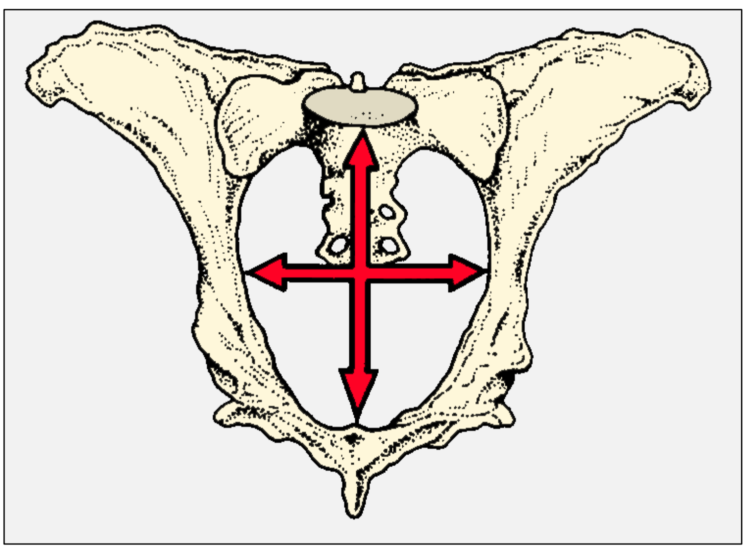


Figure 1. Endocrine and ovarian changes associated with puberty onset (adapted from Day and Anderson, 1998; Anderson et al., 1991).

Pelvic measurements. Pelvic measurements should be used in addition to, not in place of, selection for size, weight, and above all fertility (Bellows and Staigmiller, 1990). Producers should be aware that selection for pelvic area will not likely result in increased pelvic dimensions alone, but may result in increased size of the entire skeleton and animal (Morrison et al., 1986). This can be minimized in a multiple trait selection program with pressure to moderate mature size and improve direct calving ease. Pelvic measurements can be used successfully to identify abnormally small or abnormally shaped pelvises. These situations, left unidentified, often are associated with extreme dystocia, resulting in Cesarean delivery and even death of the calf or dam (Patterson et al., 1992).

Pelvic area is an effective indicator of maternal calving ease (Bellows and Staigmiller, 1990). Selection of sires with high CED EPD mated to heifers that are screened for pelvic area contribute to a decrease in the incidence and (or) severity of calving problems and minimize calf losses from dystocia. Bullock and Patterson (1995) reported that puberty exerts a positive influence on pelvic width and resulting pelvic area in yearling heifers; however, the preceding differences that were seen among heifers as yearlings did not carry through to calving as two-year-olds. Therefore pubertal status of the heifer at the time prebreeding examinations are performed should be considered in selection (culling) decisions based on pelvic measurements and contemporary grouping for genetic analysis of pelvic measurements. The data suggest that puberty plays a role in pelvic size as yearlings, but once heifers reach puberty the effects may no longer be present. An independent culling level for pelvic size in heifers that are at different stages in their reproductive development appears to be more restrictive for those heifers that are peripubertal at the time of the exam. Heifers with a pelvic area less than 150 cm^2 at the time a prebreeding exam is performed should be re-measured at the initial pregnancy exam within 90 days from the start of the breeding season. At this time the heifer is expected to have attained a minimum pelvic area of 180 cm^2. Growth of the pelvis at yearling age is based on BIF guidelines, suggesting an anticipated growth rate of 0.27 cm^2/day. Due to the issues described above in using pelvic measurements in phenotypic selection, pelvic measurements would be best utilized in a national cattle evaluation setting.

While pelvic area can be used as an effective indicator trait of maternal calving ease, it may also be helpful to predict earlier maturing heifers. As previously discussed, earlier maturing heifers have greater lifetime production, and effective measures of fertility in beef cattle are sorely lacking.



Management considerations related to use and application of RTS. The reproductive tract scoring system can be used to select heifers that are "reproductively ready" for the breeding season and thus minimize carrying costs of heifers that will very likely fail to cycle and conceive. Reproductive tract scores, when timed appropriately, serve as a useful indicator in determining whether heifers are ready to be placed on an estrous synchronization protocol and are useful too, in determining the most appropriate method of estrous synchronization to use. Reproductive tract scores (RTS) should be performed on heifers no more than two weeks before administering an estrous synchronization protocol; and are considered "ready" to be placed on a progestin-based estrous synchronization protocol when at least 50 percent of the heifers are assigned a RTS of 4 or 5 (Patterson et al., 1999).

Heifers that are retained for breeding should not have received growth promoting implants during the suckling period as calves (Bartol et al., 1995). Heifer calves administered implants beginning on or before postnatal day 45, experience developmental loss of adult uterine endometrial area and glandularity. These changes cannot be considered desirable effects, because both maternal uterine tissues and related uterine secretions affected by implant use are recognized to play critical roles in support of conceptus development (Bartol et al., 1995). The significance of these findings as they relate to RTS pertain to situations involving heifers in which the management history of the heifer is unknown at the time the prebreeding examination is performed. The changes that occur in uterine morphology as a result of implant administration are in many cases palpable per rectum at the time the RTS is performed.

PREGNANCY EXAMINATION. An initial pregnancy examination should be performed within 90 days from the start of the breeding season. Individual animal identification, pregnancy status and fetal age (in days) should be recorded. Herds utilizing artificial insemination should report breeding dates. Pregnancy determination at this point relative to the start of the breeding period enables the veterinarian to more accurately determine fetal age and success of the heifer's first breeding period.

- In situations where artificial insemination is performed, heifers should not be exposed for natural service for a minimum of:
    - 14 days after AI.

National cattle evaluations have typically used a success/failure measurement of heifer pregnancy to calculate EPDs. But, the information content in measures of when in the breeding season a heifer conceives (days pregnant) is greater than a success/fail measurement. This is simply due to the greater information content in quantitative versus categorical measures (Kizikaya, Fernando, and Garrick, 2014).While not all producers will provide pregnancy examination reports, using the information from those that do would increase the reliability of heifer pregnancy EPDs.

HERITABLE VARIATION. Previous work by breed associations has shown that heifer fertility is a heritable trait. The American Angus Association reports a heritability of 0.14 for heifer pregnancy (http://www.angus.org/nce/heritabilities.aspx) and the American Hereford Association reports a heritability of 0.27 for heifer calving rate EPD (http://hereford.org/content/heifer-calving-rate-epds). Our RTS heritability estimate of 0.26 from 180 Angus sires and 1,556 heifers in the Show-Me-Select Replacement Heifer Program (SMS) closely matches previously published estimates of 0.32 (Anderson et al. 1991). Heritability estimates for pelvic width vary from 0.38 to 0.82 (Morrison, Williamson, and Humes 1986; Nelsen et al. 1986), and in our data we estimate a heritability of 0.45. Pelvic height heritabilities vary from 0.10 to 0.59 (Morrison, Williamson, and Humes 1986; Nelsen et al. 1986), and in the SMS data we estimate a heritability of 0.31. Clearly, there is ample genetic variation present for genetic evaluation of RTS, pelvic area, and days pregnant in cattle.

CONCLUSION. Reproductive biologists have spent the last three decades developing and refining measures of puberty and reproductive success in cattle. But, animal breeders and quantitative geneticists have not employed these methods in the prediction of beef cattle fertility. We now propose the standardization and reporting of reproductive tract scores (RTS), pelvic measurements, and pregnancy diagnosis within 90 days of the start of the breeding season to use in selecting replacement heifers and national cattle evaluation.

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PHENOTYPIC DATA COLLECTION FOR REPLACEMENT BEEF HEIFERS

PREBREEDING

- Farm/ranch name & address
- Animal ID
- Birth date
- Breed or breed cross
- Sire
- Dam
- Weight[a]
- Hip height[a]
- Reproductive tract score[a]
- Pelvic height[a]
- Pelvic width[a]
- Pelvic area[a]
- Hair or blood sample(s) for genomic testing

  [a]Prebreeding exams should be performed 4 to 6 weeks prior to breeding.

BREEDING

- Breeding method
  - AI
  - Natural service
  - AI followed by natural service clean-up
- Estrous synchronization method
  - No synchronization
  - PG
  - MGA-PG
  - 5-day CO-Synch + CIDR
  - 7-day CO-Synch + CIDR
  - 14-day CIDR-PG
  - Others as developed
- Estrous detection
  - No detection
  - Visual
  - Aids
    - Estrotect
    - HeatWatch
    - Other
- AI breeding[b]
  - Heat detection
  - Heat detection & TAI
  - Fixed-time AI
  - Split-time AI
- AI sire
  - Conventional semen
  - Sex-sorted
- AI technician
  - Lay
  - Professional

[b]Following AI, heifers should not be exposed to clean-up bulls for 14 days to provide more accurate determination of AI versus natural-service sired pregnancies.

PREGNANCY DIAGNOSIS

- Examiner
- Method
  - Ultrasound
  - Palpation
- Pregnancy status
  - AI
    - Fetal age
  - Natural service
    - Fetal age
  - Open/short
- Fetal sex