Theriogenology 84 (2015) 358–364

Contents lists available at ScienceDirect

Theriogenology

journal homepage: www.theriojournal.com

Factors associated with the differential in actual gestational age and gestational age predicted from transrectal ultrasonography in pregnant dairy cows

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ARTICLE INFO

Article history:
Received 14 November 2014
Received in revised form 20 March 2015
Accepted 24 March 2015

Keywords:
Ultrasonography
Gestational age
Pregnancy loss
Stillbirth
Dystocia

ABSTRACT

The objective of the study was to determine (1) how gestational age predicted using transrectal ultrasonography related to actual gestational age derived as the number of days from the most recent artificial insemination date, (2) what factors, if any, were associated with the differential between the two measures, and (3) the association between this differential in gestational age and the likelihood of subsequent pregnancy loss, stillbirth, or calving dystocia. The data set contained 7340 ultrasound records from 6805 Holstein Friesian dairy cows in 175 herds. Ultrasonography assessment underestimated gestational age relative to days since last service by 0.51 days (standard error [SE]: 0.040), although the differential was less during embryonic development phase (i.e., ≤42 days of gestation; mean overestimation of 0.31 days) versus fetal development phase (i.e., >42 days of gestation; mean underestimation of 0.81 days). Predicted calving date calculated from ultrasonography was 1.41 days (SE: 0.040) later than the actual subsequent calving date and was, on average, 0.52 days later than predicted calving date, assuming a gestation length of 282 days. Parity of the dam ($P < 0.05$), stage of pregnancy ($P < 0.001$), and sex of the calf born ($P < 0.001$) were all associated with the differential in gestational age based on ultrasonography versus days since last service. No obvious trend among parities was evident in the difference between the methods in predicting gestational age. Ultrasonography underestimated gestational age by 0.83 (SE: 0.15) days in parity 5+ cows and underestimated gestational age by 0.41 (SE: 0.14) days in the first-parity cows. Relative to gestational age predicted from the most recent service, ultrasonography underestimated gestational age by 0.75 (SE: 0.13) days for heifer fetuses and underestimated gestational age by 0.36 (SE: 0.13) days for bull fetuses. The heritability of the differential in gestational age between the methods of prediction was low 0.05 (SE: 0.022), corroborating heritability estimates for most cow reproductive traits. Overestimation of gestational age using ultrasonography was associated with an increased likelihood of pregnancy loss ($P < 0.001$). Gender of calf born ($P < 0.001$), sire breed of calf ($P < 0.001$), and parity ($P < 0.001$) were all associated with gestation length. Gestation length was 1.27 days longer (SE: 0.01) for bull calves compared to heifer calves. Calves from beef sires had a longer gestation length than calves from dairy sires, and older parity cows had a longer gestation length than younger cows. The results highlight factors associated with differences in gestational age obtained from ultrasonography and insemination data and illustrate the value of ultrasonography for the prediction of calving date and pregnancy loss.

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http://dx.doi.org/10.1016/j.theriogenology.2015.03.023

1. Introduction

Ultrasonography is a key management component of dairy and beef herds and is used routinely to diagnose pregnancy, establish fetal age and gender, and identify anomalies in embryonic or fetal development. Delayed or accelerated fetal growth can be quantified using ultrasonography, and these growth patterns may have implications on gestation, calving events, and subsequent performance of both the cow and the calf born.

Size and differentiation of maternal and fetal components measured using ultrasonography relative to actual gestational age have been exploited to elucidate reliable parameters to predict gestational age in cattle [1–4], goats [5–7], and humans [8,9]. The manifestation of a heartbeat, crown rump length, occiptonasal length, orbital diameter, abdominal diameter, umbilical cord diameter, uterine diameter, amniotic sac diameter, thoracic diameter, head circumference, and chest depth are all proposed approaches to estimate gestational age [1–7]. The error rate for estimated gestational age varies among species and the parameter(s) measured, but in cattle, the crown to rump length is thought to be the most accurate predictor of gestational age [1].

Studies in humans concluded that restricted *in utero* development is linked to preterm birth, smaller birth size, and an increased risk of perinatal and infant death [10,11]. Accelerated *in utero* growth is associated with prolonged labor, dystocia, fractures, larger birth size, and perinatal mortality [12].

In cattle, heifer calves, twin calves, and calves born to primiparous cows tend to be lighter at birth compared to bull calves, singletons, or calves born to multiparous cows, respectively [13–15]. Heavier birth weight is associated with greater calving difficulty [16], which is known to have unfavorable repercussions on subsequent reproductive performance and milk yield of the dam [16–18]. A positive relationship between larger developing embryos and pregnancy loss has also been established, although this relationship was based on embryos cultured *in vitro* [19,20]. Intrauterine growth retardation in cows occurs primarily through inappropriate maternal nutrition or reduced uterine capacity (e.g., multiple pregnancies) that can limit conceptus growth [21]. As well as reducing fetal weight, intrauterine growth retardation have been associated with asymmetric organ development [22] and long-term glucose dysregulation and cardiac dysfunction in several species [23–25].

The objective of the present study was to (1) establish the predictive ability of gestational age using transrectal ultrasonography compared to gestational age based on the most recent service, (2) identify the factors associated with the differential in predicted gestational age based on the two approaches, and (3) quantify the association between the differential in predicted gestational age and the likelihood of pregnancy loss, stillbirth, or calving difficulty. Results from this study may be useful to develop appropriate farm management techniques for animals at risk, especially in relation to subsequent calving events.

2. Materials and methods

2.1. Data

Reproductive tract ultrasound examinations were performed by a single technician for a commercial company (Reprodoc Ltd., Fermoy, County Cork, Ireland; http://www.cowsdna.com) on 39,026 lactations on 35,700 cows in 358 herds between January 2010 and May 2012. Ultrasonography was performed transrectally using a real-time β-mode ultrasound scanner with a 5-MHz transducer. Single and multiple pregnancies were diagnosed by the presence of a viable conceptus(s), and both age and fetal sexing were estimated. Only pregnancies estimated to be between 25 and 110 days ($n = 7531$) were retained. Aging of the embryo or fetus was determined by size (length and diameter) and the manifestation of several embryonic or fetal markers unique to key stages of development. The embryo was first visible using ultrasonography between 25 and 27 days of gestation. A heartbeat was detectable by Day 30 of gestation, when the embryonic diameter was approximately 10 mm at its widest point. Differentiation of the head and abdominal regions began from Day 35 of gestation, and budding of the limbs was identifiable from Day 45 of gestation. From 50 days of gestation, male and female fetuses could be differentiated relative to the location of the genital tubercle. The genital tubercle appears as two parallel white lines. In bull fetuses, the genital tubercle is located at the base of the umbilical cord, and in heifer fetuses, it is located behind the hind legs. Also, the scrotum is located between the hind legs in bull fetuses. Crown to rump length, abdominal, thoracic, and head circumferences were used as fetal parameters to estimate gestational age. The technician undertaking the ultrasound examinations was unaware of the service dates when estimating gestational age from the ultrasound.

Individual cow supplementary data from the Irish Cattle Breeding Federation database were also available. Supplementary data included parity, date of previous calving, date of subsequent calving, insemination dates, date of ultrasound scan, number of calves recorded at birth, gender of calf born, breed of dam and sire of the calf, dystocia in the subsequent calving, and stillbirths. Only dairy cows with greater than 75% of known breed fraction were retained for analysis. Dystocia was recorded by producers on a scale from 1 to 4 (1 = no assistance or unobserved; 2 = slight assistance; 3 = severe assistance; and 4 = veterinary assistance or including cesarean). Stillbirths were coded as a binary variable (0 = not stillborn; 1 = stillborn). Only records where gestational age, obtained from service data, was within 15 days of the gestational age estimated from ultrasonography were retained for analysis; 2.33% of the data were discarded on the basis of this edit. Ultrasound scans associated with a multiple birth were excluded, and parity records greater than or equal to five were combined into a single parity (i.e., parity 5+). Stage of gestation was divided into the embryonic stage (≤42 days of gestation) or the fetal stage (≥43 days of gestation) on the basis of gestational age predicted from the most recent service date.