Use of ultrasonographic fetometry for the estimation of days to kidding in dairy does

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ABSTRACT

The objective of this study was to predict the number of days to kidding in dairy goats by ultrasonographic measurement of three consecutive ribs and intercostal spaces or trunk diameter of fetuses. Two groups of primiparous and multiparous goats were examined by transabdominal ultrasonography. Actual kidding date was used to compute the true number of days to kidding relative to the ultrasound examination day. Linear regression models were built to predict days to kidding based on fetal measurements, parity, and number of kids. The model using the width of three consecutive ribs and intercostal spaces (n = 29 goats) showed a curvilinear relationship between days to kidding and rib distance ($R^2 = 0.60$; $P < 0.01$). The trunk diameter model (n = 135 goats) showed a curvilinear relationship between days to kidding and trunk diameter with an effect of parity ($R^2 = 0.81$; $P < 0.01$).

1. Introduction

Ultrasonography is routinely used for pregnancy diagnosis in dairy goat operations [1]. In addition to determination of pregnancy status and litter size, prediction of the kidding date could be useful for the grouping of does by expected kidding date and for the management of possible pre-partum diseases. Various ultrasonographic fetal measurements have been evaluated for the estimation of gestational age in goats. Parameters previously reported as highly correlated with gestational age include biparietal diameter, heart axis length, trunk diameter, crown-rump length, femur length, and length of 6 successive vertebrae [2—5]. However, the applicability of the findings of many studies on fetal measurements is limited by a number of factors. For example, most studies included a small number of goats on which measurements were repeated over time (expected to be correlated within goat). Secondly, some of the fetal measurements may be limited by gestational age or fetal posture at the time of examination [2,6]. Many of these variables may also be difficult or impractical to measure in a timely fashion when large groups of animals are examined [7]. Placentomes are easy to measure [4], but poorly correlated with gestational age in some studies, which was attributed to the variable size of the placentomes in different portions of the uterus [3,5,7]. While fetal trunk diameter (TD) is easy to measure [3], data from studies on TD in goats is limited to Egyptian, Shiba, and Korean breeds [3—5]. Because fetal measurements can be influenced by breed [2], regression equations reported in these studies may not accurately predict gestational age or days to kidding in other breeds, such as European dairy breeds. Previous studies have also not investigated the effect of parity and number of kids on fetal measurements. Hence, the objective of this study was to predict the number of days to kidding in dairy goats by ultrasonographic measurement of the width of three consecutive ribs and intercostal spaces (RS) or trunk diameter, while also considering parity and litter size.

2. Materials and methods

2.1. Animals

The study design was a cross-sectional study. Data were

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collected during routine on-farm ultrasound examinations for pregnancy. Two groups, expected to be in two different stages of gestation were examined for pregnancy on a dairy goat operation located in Northeast Missouri that managed approximately 1400 goats at the time of the study. The herd was in year-round production. The goats were cross-bred, with breeds including mostly Saanen, as well as Alpine, Toggenburg, and La Mancha. Group 1 (n = 47) was used to study the relationship between fetal RS measurement (see below) and days to kidding. This group was composed of primiparous (n = 27) and multiparous (n = 20) goats. The group was subjected to an estrus synchronization protocol using progesterone vaginal implants (CIDR, Zoetis, Kalamazoo, WI) for 12−14 d, followed by administration of prostaglandin (unknown product and dosage) on the day of implant removal and exposure to the bucks starting on that same day. Time between introduction of the buck and ultrasound examination was not available at the time of examination. Group 2 (n = 218) was used to study the relationship between fetal trunk diameter (see below) and days to kidding. This group was composed of primiparous (n = 126) and multiparous (n = 92) goats. This group was exposed to the bucks in the natural breeding season (October) without any form of estrus synchronization. Ultrasound examinations of does in Group 2 were performed 87 and 93 d after introduction of the bucks in the primiparous and the multiparous groups, respectively. The bucks were of Saanen and Alpine breeds.

2.2. Ultrasonography

Transabdominal ultrasonography was performed on a single day in Groups 1 and 2, using a portable ultrasound unit (Edge Ultrasound System, SonoSite, Inc., Bothell, WA) equipped with a sector-array transducer (C60xi/5-2 MHz Transducer, FUJIFILM SonoSite, Inc., Bothell, WA). Goats were restrained in a standing or laterally recumbent position. Isopropyl alcohol was used as coupling medium and the transducer was placed on the skin in the ventrocaudal area of the right flank, just cranial to the udder. Pregnancy was first confirmed by visualization of at least one fetus. For Group 1, fetal RS was defined as the total width encompassing three consecutive ribs and their adjacent caudal intercostal space. For Group 2, measurement of the TD was defined as the maximum abdominal diameter in a transverse or sagittal view. All dimensions were measured with the ultrasound machine's electronic calipers on fixed images. When multiple fetuses were present, measurement was performed on the fetus closest to the transducer. Each measurement and the goat's identification number were recorded at the time of examination. All examinations were performed by the same ultrasonographer (DHV), and all measurements on fixed images were made by the same assistant (VBG). The farm personnel recorded the actual kidding dates and number of kids produced by each doe. The farm personnel also recorded abortions (defined as expulsion of nonviable fetuses), as well as premature kids (defined as kids that were alive at birth, but had low birth weights, non-erupted incisors, and short hair). Data for parity, kidding date, and number of kids were retrieved from the farm records, and goats with incomplete data were excluded from the study. Data from does that aborted or delivered premature kids were also excluded from analysis.

2.3. Statistical analysis

Parity data were converted to a dichotomous variable (primiparous or multiparous). Days to kidding were calculated as the difference between the kidding date and the date of ultrasound examination. Based on a median gestation length of 150 d [8], gestational age at the time of ultrasound examination was

calculated as days to kidding subtracted from 150 d. Based on gestational age, month in gestation was categorized as 0−30 d (1st month), 31−60 d (2nd month), 61−90 d (3rd month), 91−120 d (4th month), and greater than 120 d (5th month).

Linear regression models were built with days to kidding as the dependent variable, RS or TD as the primary independent variable, and number of kids and parity as the other independent variables. Linearity of the relationship between RS or TD and days to kidding was assessed using polynomial square and cubic terms, and polynomial terms that were statistically significant were kept for inclusion in the model. Associations between variables were evaluated, and independent variables associated ($P < 0.05$) with days to kidding were kept for inclusion in the model. Interactions between independent variables were evaluated. Variables found to be significantly associated with days to kidding were first added to the model one by one, and then interactions were tested for inclusion (forward stepwise). Normality and homoscedasticity of residuals were visually assessed. Statistical significance was set at $P < 0.05$. Statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, NC, USA).

3. Results

3.1. RS measurement

In Group 1, after exclusion of non-pregnant goats (n = 6) and goats with incomplete data (n = 12), the model included data from 16 primiparous and 13 multiparous goats. The numbers of kids delivered by primiparous goats were one (n = 10) or two (n = 6). The numbers of kids delivered by multiparous goats were one (n = 3), two (n = 9), or three (n = 1). Overall, median (range) RS for all goats was 2.83 (0.89−4.21) cm. Median (range) RS was 2.65 (1.73−4.21) cm for primiparous goats and 2.88 (0.89−3.78) cm for multiparous goats. Median (range) days to kidding was 33 (17−64) d for primiparous and 35 (13−76) d for multiparous goats. Inversely, the calculated median (range) gestational age was 117 (86−133) d for primiparous goats and 115 (74−137) d for multiparous goats. Hence, two goats were in the 3rd month of gestation, 19 goats were in the 4th month, and 8 goats were in the 5th month. Visual assessment of the relationship between days to kidding and RS revealed a curvilinear relationship. There was no association of either parity or number of kids with days to kidding or RS. The final model for RS in Group 1 was as follows:

$$\text{Days to kidding} = 71.77 - 32.98^*(\text{RS-1}) + 6.19^*(\text{RS-1})^2$$

Estimates of the variables included in the final model are presented in Table 1. The model explained 60% of the variation in days to kidding ($R^2 = 0.60$; $P < 0.01$). Days to kidding predicted by the model for various RS are shown in Table 2. Fig. 1 shows the relationship between predicted days to kidding and RS measurements.

Table 1
Linear regression model to predict days to kidding using the width of three consecutive fetal ribs and intercostal spaces, based on observations from 29 dairy goats between 13 and 76 days from kidding.

Parameter	Estimate	Standard Error	P-value
Intercept[a]	71.77	6.42	<0.01
RS_ct[b]	−32.98	7.13	<0.01
RS_ct_sq[c]	6.19	1.99	<0.01

[a] Days to kidding of a goat with a measured RS of 1 cm.
[b] RS value centered on 1 cm.
[c] Square term of centered RS value.