

A meta-analysis of the relationship of maternal weight and fetal sex on uterine blood flow and maternal heart rate in beef cows from mid to late gestation

Amelia R. Tanner¹, Marc L. Bauer¹, Victoria C. Kennedy¹, Bethany R. Mordhorst², Leticia E. Camacho³, Kendall C. Swanson¹ and Kimberly A. Vonnahme¹

Uterine blood flow plays a critical role in the development of the conceptus, allowing for the maternal-fetal exchange of nutrients, hormones, and wastes. This analysis found that cows carrying bull calves have higher uterine blood flow than those carrying heifer calves which could be contributing to heavier birth weights. Additionally, heavier cows tended to have greater uterine blood flow throughout mid-to-late-pregnancy, accompanied by higher heart rates.

Summary

Our objective was to examine the relationships among maternal body weight (BW), fetal sex, uterine blood flow and maternal heart rate in beef cows during mid to late gestation. Four studies were used in the analyses, with blood flow measurements taken via Doppler ultrasonography on four days of gestation from 108 beef cows, which resulted in 333 total observations. Fetal sex, maternal BW class (100-pound increments) and BW class by fetal sex interactions were analyzed with generalized least squares (mixed procedure of SAS) with repeated measures. Day of gestation was included as a covariate, and treatment was nested within study. Linear, quadratic and cubic orthogonal contrasts were tested. Cows carrying bull calves ($n = 82$) had greater ($P = 0.03$) uterine blood flow from days 100 to 250 of gestation, compared with cows carrying heifer calves ($n = 26$; 4.9 vs. 4.1 ± 0.3 gallons/minute [gal/min]). As maternal BW

increased, uterine blood flow tended ($P = 0.09$) to increase linearly. Maternal heart rate also increased linearly ($P = 0.02$) as maternal BW increased. Fetal sex did not impact maternal heart rate ($P = 0.13$). In conclusion, the increase in uterine blood flow for male progeny may be contributing to heavier birth weights when compared with their female counterparts. Also, increasing maternal weight may be associated with increased uterine blood flow and heart rate. The reason bull calves are heavier than heifer calves at birth may be due to the male's ability to increase uterine blood flow.

Introduction

Little is known about the physiological role of fetal sex or maternal body weight on total uterine blood flow and maternal heart rate. Sex-specific differences in uterine blood flow have been observed at 120 days of gestation in beef heifers fed a protein-restricted diet, with heifers carrying male progeny experiencing higher uterine blood flow (Hernandez-Medrano et al., 2015). Those sex-specific blood flow differences

could not be detected after day 120 of pregnancy or independent of maternal diet.

The objective of this analysis was to examine the relationships among maternal BW, fetal sex, uterine blood flow and maternal heart rate in beef cows during mid to late gestation. We hypothesized that heavier cows would have greater uterine blood flow and heart rates, and cows carrying bull calves would have greater total uterine blood flow.

Experimental Procedures

A total of 108 multiparous Angus or Angus x Continental cows from four independent studies were included in the analysis. Uterine blood flow changes were tracked from day 100 to day 250 of pregnancy through transrectal Doppler ultrasonography measurements of the uterine artery with the ALOKA 3500 ultrasound.

A 7.5 MHz finger probe was inserted into the rectum and the bifurcation of the external and internal iliac arteries were identified. Placement of the probe was immediately posterior to the first branch of the external iliac artery, measuring the descending uterine artery.

Three cardiac cycle waveform profiles from two to three ultrasound measurements were collected of the uterine arteries ipsilateral (I; same horn) and contralateral (C; opposite horn) to the conceptus, with an average of all measurements accounting for one observation ($n = 333$; $I + C = \text{Total}$).

¹Department of Animal Sciences, NDSU

²University of Missouri, Columbia

³University of Arizona, Tucson

Fetal sex was confirmed at parturition (bull, n= 82; heifer, n=26). Fetal sex, BW class (100-pound increments), and BW class by fetal sex interactions were analyzed using generalized least squares with the mixed procedure of SAS with cow as the repeated measure. Day of gestation was included as a covariate and treatment was nested within study.

Linear, quadratic and cubic orthogonal contrasts for BW class also were tested. A P-value ≤ 0.05 was considered significant and a P-value of ≤ 0.09 was considered a tendency.

Results and Discussion

As illustrated by Figure 1, cows carrying bull calves had greater ($P = 0.03$) uterine blood flow from days 100 to 250 of gestation, compared with cows carrying heifer calves (4.99 vs. 4.1 ± 0.3 gal/min). Additionally, we found no interaction ($P = 0.20$) between maternal BW class and the sex of the progeny.

Figure 2 shows that fetal sex did not impact maternal heart rate ($P = 0.13$) and no maternal BW class or fetal sex interactions influenced maternal heart rate ($P = 0.21$). One possible explanation for this phenomenon is that the male fetus produces some factor to increase maternal blood flow by expanding the maternal arteries without impacting heart rate.

Linear, quadratic and cubic contrasts (Figure 3) were examined to determine the relationship between maternal BW and uterine blood flow. Uterine arterial blood flow tended ($P = 0.09$) to increase linearly at a rate of 1.6 quarts per 100 pounds as maternal BW increased, thus heavier cows experienced greater uterine blood flow independent of the day of gestation.

The relationship between maternal heart rate and maternal BW also was analyzed with linear, quadratic and cubic contrasts (Figure 4). As maternal BW increased, maternal heart rate also increased linearly ($P = 0.03$) at a rate of 1.4 beats per min per 100 pounds of BW.

As expected, heavier cows have

increased uterine blood flows and heart rates. Additionally, fetal sex contributes to total uterine blood flow; cows carrying bull calves displayed greater total uterine arterial blood flow. One probable cause for increased bull weights at birth could be the male fetus's ability to increase local factors in the uterus or pla-

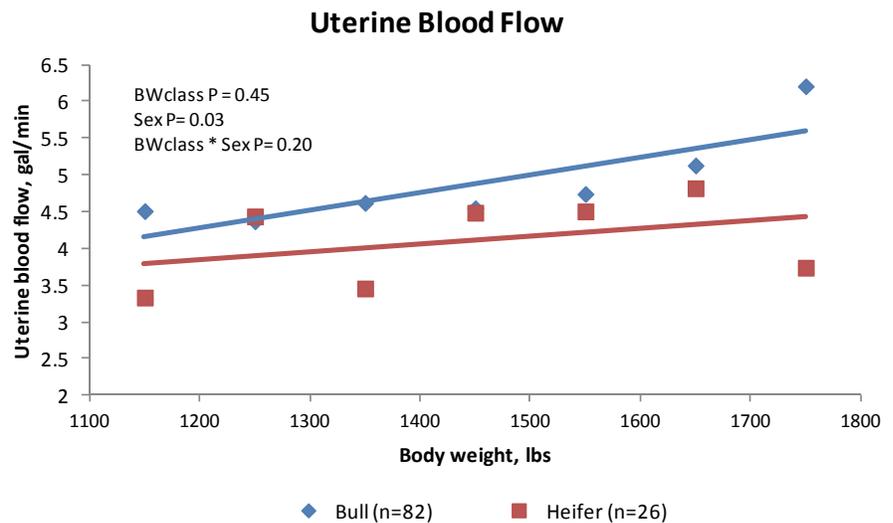


Figure 1. Effects of maternal BW class and fetal sex on uterine blood flow (milliliters/minute).

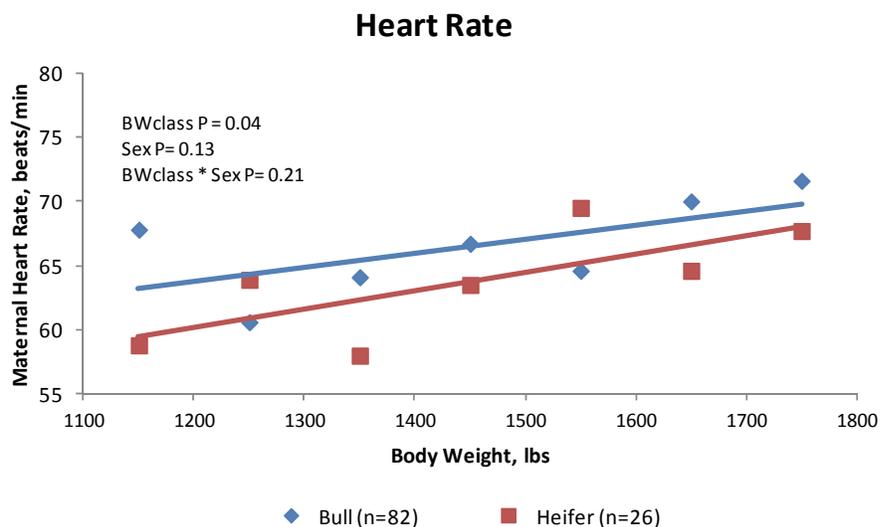


Figure 2. Effects of maternal BW class and fetal sex on maternal heart rate, beats/minute.

centa that drive uterine blood flow throughout mid to late gestation.

Because fetal sex did not increase the maternal heart rate, this gives further evidence that bull calves may be causing the release of some factor that increases uterine blood flow.

Literature Cited

Hernandez-Medrano, J.H., K.J. Copping, A. Hoare, W. Wapanaar, R. Grivell, T. Kuchel, G. Miguel-Pacheco, C. McMillen, R.J. Rodgers and V.A. Perry. 2015. Gestational dietary protein is associated with sex specific decrease in blood flow, fetal heart growth and post-natal blood pressure of progeny. PLoS ONE 10(4): e0125694.

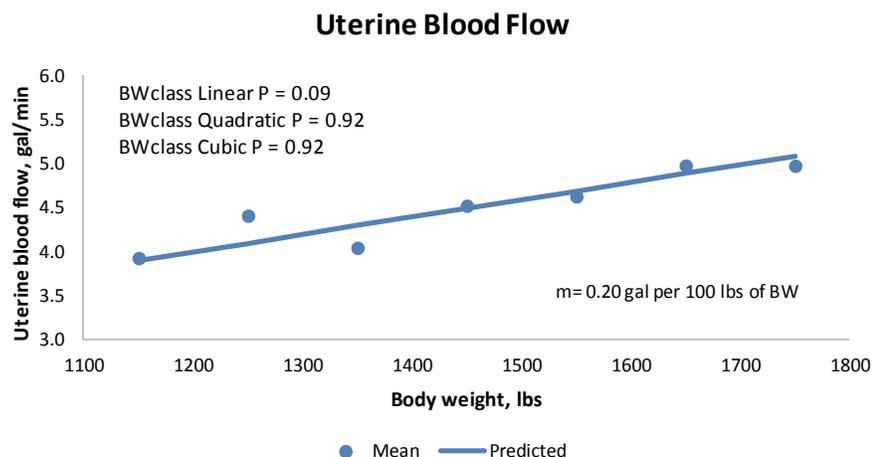


Figure 3. Effects of maternal BW class on uterine blood flow (gallons/minute).

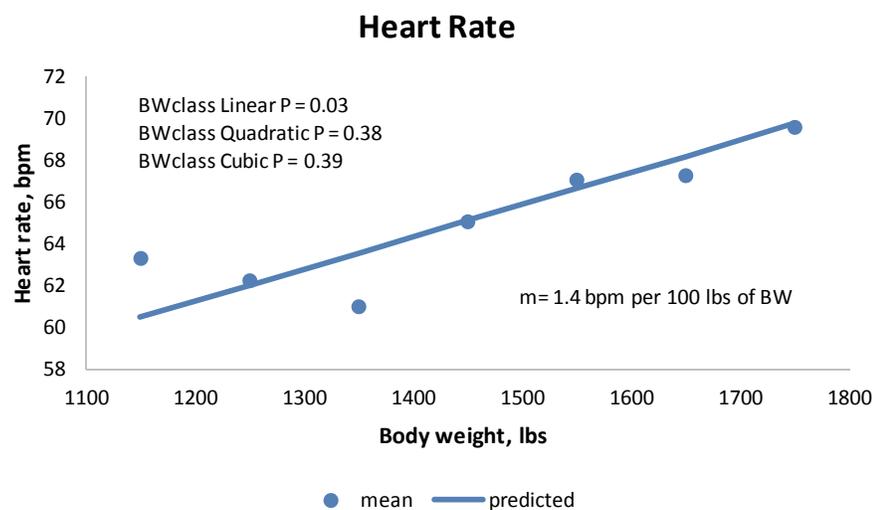


Figure 4. Effects of maternal BW class on maternal heart rate, beats/minute.