EFFECT OF HEAT STRESS ON EARLY EMBRYONIC DEVELOPMENT AND SURVIVAL IN THE BEEF COW

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Story in Brief

Thirty-two cyclic multiparous Hereford and Hereford X Angus cows were utilized to determine the effects of heat stress on early embryonic development and survival. On Day 7 of pregnancy, cows were fitted with indwelling jugular cannulae and placed in one of the following treatment groups: Control (22°C, 25% relative humidity), mild heat stress (37°C, 27% relative humidity) and severe heat stress (37°C, 40% relative humidity). Between days 8-16 of pregnancy, heat stressed cows had increased respiration rates, rectal temperatures, water intake and decreased hematocrit and plasma protein compared to controls. Plasma progesterone was elevated while thyroxine was decreased in severe heat stress when compared to mild stress and control groups. Cows were slaughtered on Day 17 of pregnancy to determine pregnancy status. There was a trend towards decreased conception rates with increasing thermal stress. Conceptus and corpus luteum wet weights were decreased in severe and mild heat stressed cows compared to controls. This study indicates that heat stress during early pregnancy (days 8-16) in the bovine can cause reduced conceptus weights and may increase embryonic mortality.

(Key Words: Heat Stress, Progesterone, Thyroxine, Conceptus, Corpus Luteum, Reproduction)

Introduction

Elevated environmental temperature and humidity close to the time of insemination result in reduced conception rates and altered hormone patterns in the beef cow. Previous work in the gilt and ewe indicates that high ambient temperature during early pregnancy results in reduced conceptus development, fetal degeneration and lower pregnancy rates. The blastocyst appears to be most susceptable to thermal stress during the first 2 to 3 weeks after insemination, a time period characterized by rapid embryonic development, growth, and attachment to the uterine endometrial surface. The purpose of this study was to determine the effect of elevated ambient temperatures during the second and third week of pregnancy on the maternal endocrine profiles and embryonic development in the beef cow.

Materials and Methods

Thirty-two cyclic multiparous Hereford and Hereford X Angus cows between 4 and 11 years of age were assigned randomly to either a control (C, n=11), mild heat stress (MHS, n=9) or severe heat stress (SHS, n=11) treatment. Estrous cycles were synchronized with Lutalyse[6] to group cows

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for placement in the environmental chamber, with the first day of estrus designated as Day 0 of pregnancy. Cows were pen mated to Angus and Hereford bulls of proven fertility. Following the insertion of an indwelling jugular cannulae on Day 7, groups of 3 or 4 cows from the same treatment were transported to the environmental chamber where treatments were applied from Day 8 through 16. Control groups were placed in a thermal neutral environment of 22±1°C and 25±10% relative humidity for 24 hours. Mild heat stress and severe heat stress treatment groups were maintained at 37±1°C between 0700-1900 hours which was decreased to 33±1°C between 1900-0700 hours to allow cows to dissipate some of the heat load during the evening hours. The relative humidity was maintained at 27±2% in the MHS environment while relative humidity was increased to 40±2% in the environment of the SHS groups. All cows were individually fed a 20% crude protein maintenance diet (17.6 kg/cow/day) consisting mainly of cottonseed hulls, rolled corn and soybean meal.

Rectal temperature, respiration rate and water intake were taken twice daily at 0700 and 1900 hours from Day 8 through 16. Blood samples (20 ml) were collected at 1900 hours for progesterone and thyroxine analysis. All samples were placed immediately on ice until centrifugation at 2,000 X g for 30 minutes. Plasma samples were stored at -20°C until analyzed. Hematocrit was immediately analyzed from the collected samples and the resulting plasma was used to analyze plasma protein using a refractometer. Plasma thyroxine and progesterone concentrations were quantified by radioimmunoassay. Rectal temperature was monitored with a digital rectal thermometer while respiration rate was measured by counting flank movements per minute. Water intake was monitored from a calibrated automatic drinking device. All cows were fed at 0700 hours with feed consumption measured at 1900 hours.

On Day 17, cows were transported to a local slaughter house where the uterus was recovered within 15 minutes after exanguination. The uterus was immediately placed on ice and transported to the laboratory (15 km). The uterus was trimmed free of the mesometrium and the contralateral and ipsilateral horn to the corpus luteum flushed separately with 20 ml of 0.9% saline. Pregnancy was confirmed by the presence of a conceptus which was immediately weighed (wet weight). The corpus luteum was dissected from the ovary and trimmed free of the surrounding connective tissue for measurement of tissue wet weight.

Physiological responses and plasma hormone trends of treatments were analyzed by least-squares analysis of variance. Day trends were characterized by polynomial curves, whereas individual treatment and treatment X day means were estimated as least-squares means. Data were analyzed with time used as a continuous independant variable.

Results and Discussion

The physiological responses in this experiment indicate that cows in both MHS and SHS groups were exposed to a higher effective heat load than Control cows (Table 1). The elevation of rectal temperatures indicate that the heat stressed groups were absorbing heat at a greater rate than could be dissipated, thus stimulating an increase in respiration rate as cows attempted to decrease their internal body temperature by respiratory evaporation. Water consumption increased in SHS cows and tended to increase with MHS as these cows would have a higher requirement to meet the needs for evaporatory water loss. Lower hematocrit and plasma protein concentrations in the heat stressed groups may have resulted from a increase in plasma volume.

Table 1. Least-squares means of physiological and hormonal responses to Treatment.

	Control	MHS	SHS
Respiration rate, B/min	56[a]	99[b]	103[b]
Rectal temperature, °C	38.9[a]	39.3[b]	39.8[b]
Water intake, L	114.7[a]	124.2[a]	154.1[b]
Hematocrit, %	31.5[a]	30.0[b]	26.5[b]
Plasma Protein, mg%	7.3[a]	7.0[b]	7.0[b]
Progesterone, ng/ml	6.6[a]	6.8[a]	7.5[b]
Thyroxine, ng/ml	48.3[a]	47.8[a]	42.7[b]
Pregnancy rate, %	83	64	50
Conceptus wet weight, g	0.1579[a]	0.1106[b]	0.0728[b]
Corpus luteum wet weight, g	3.39[c]	2.77[d]	2.80[d]

[a,b]Least-squares means with different superscripts are different ($P<.01$).
[c,d]Least-squares means with different superscripts are different ($P<.10$).

Cows in severe heat stress attempted to lower their heat load by adjusting circulating thyroxine levels (Table 1, Figure 1). The lowering of plasma thyroxine would result in decreasing the metabolism rate and the heat produced from metabolic processes.

Plasma progesterone concentrations in SHS cows were higher than the MHS and Control cows from Day 8 through 16 (Table 1, Figure 2). Even though MHS was not significantly different than Controls, concentrations of progesterone for MHS was intermediate between Control and SHS groups.

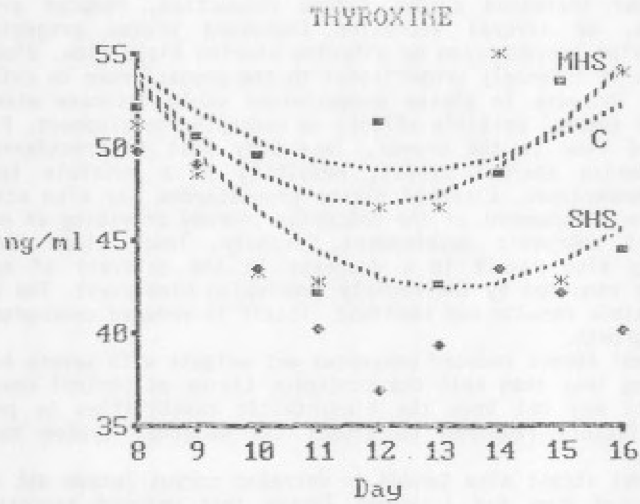

Figure 1. Least-squares regressions and least-squares means of thyroxine concentration (ng/ml) for control (C, ✱), mild heat stress (MHS, ■) and severe heat stress (SHS, ●) cows.

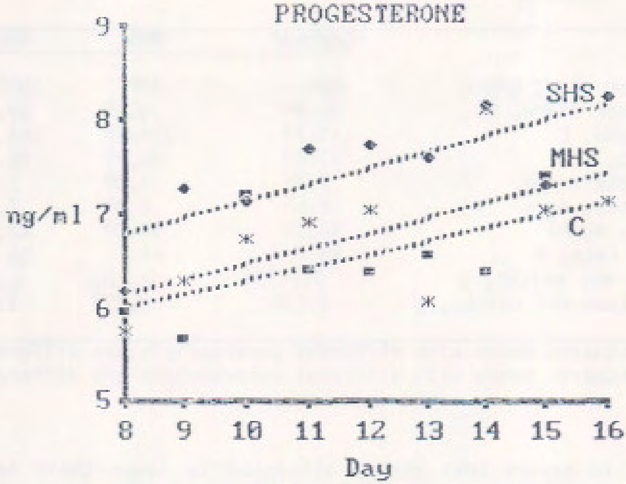

Figure 2. Least-squares regressions and least-squares means for the progesterone concentration (ng/ml) of control (C,✱), mild heat stress (MHS,■) and severe heat stress (SHS,●) cows.

It is possible that the elevation in progesterone concentration results from either increased corpus luteum production, reduced progesterone metabolism, or adrenal secretion. Increased plasma progesterone may affect bovine reproduction by altering uterine blood flow. Blood flow to the uterus is inversely proportional to the progesterone to estradiol-17B ratio. An increase in plasma progesterone would decrease uterine blood flow, with several possible effects on conceptus development. First, with less blood flow to the uterus, less body heat is transferred to the surface during thermal stress, resulting in a possible increase in uterine temperature. Elevated plasma progesterone may also act to alter the uterine environment of the conceptus thereby providing an environment hostile to embryonic development. Secondly, lower blood flow to the uterus may also result in a decrease in the delivery of nutritional substrates required by the rapidly developing blastocyst. The outcome of these possible results may manifest itself in reduced conceptus development and growth.

Thermal stress reduced conceptus wet weights with severe heat stress cows having less than half the conceptus tissue as control cows. Smaller blastocysts may not have the biosynthetic capabilities to produce the chemical factors required to signal the maternal system to maintain pregnancy.

Thermal stress also tended to decrease corpus luteum wet weights as heat stressed cows had a corpus luteum that weighed approximately .5 grams less than those of Controls. Reduced corpus luteum weights may indicate the release of prostaglandin produced by the uterus during heat stress. Should these prostaglandins escape the lumen of the uterus and enter the blood stream, their effect could be to regress the corpus and enter the blood stream, their effect could be to regress the corpus luteum and terminate pregnancy.

The purpose of this study was not to mimic heat stressed situations that the bovine female would face naturally. We attempted to place the cows in the most thermally stressful situation possible and to determine whether or not we could in fact alter bovine early embryonic development and survival during the second and third week of pregnancy.