RESEARCH REPORT

ANIMAL SCIENCE

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Title: Impact of in utero heat stress on subsequent growth, composition and reproduction – NPB #13-022

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Industry Summary:

Heat stress results in reduced feed intake, growth rate and reproductive performance, and most research has been aimed at these direct responses. It has also been shown that heat stress can reduce birth weight and increase number of stillborn piglets. Light birth weight pigs have smaller muscle fibers and adipocytes leading to less tender products, affecting the amount of marbling. Subsequent reproductive performance of piglets developing under heat stress conditions has not been reported and may magnify the true impact heat stress has on the U.S. swine industry.

This project was designed to collect data on economically important traits of growth, body composition, carcass quality, fat quality, puberty and subsequent reproductive performance on piglets developing *in utero* under heat stress (GTN) or thermoneutral (GTN) conditions.

Parity 1 females were artificially inseminated and housed under thermoneutral (GTN; 64.5-71.5ºF) or heat stress (GHS; 82.5-93ºF) daily temperature cycles throughout gestation, then lactated ~21d under TN conditions. At weaning, GHS and GTN gilts were housed together in pens of 22-25 gilts per pen. Barrows were double stocked here until approximately 55lbs (25kg), then 80 barrows were individually housed and fed in attempt to correct impact of *in utero* heat stress: a corn soybean meal diet that met (100%) or exceeded (110%) NRC lysine requirements; in the last 30 days barrows received a diet with 0 (CTL) or 7.4 ppm Paylean (PAY) until 266 lb (121kg). Weight, average daily gain (ADG), and feed disappearance (FD) were recorded. Week one weight was greater (*P*=0.03) in HS barrows (2183.00 ± 60.48 vs 1999.01 ± 59.66 g) but tended to be reduced (*P*=0.08) in HS barrows in late finishing (121.58±1.47 vs 125.26 ± 1.49 kg). In both grower (*P*=0.04) and finisher (*P*=0.05) phases, FD was greater in HS barrows (2.22 ± 0.05 vs 2.08 ± 0.05; 3.29 ± 0.08 vs 3.00 ± 0.08, respectively). PAY barrows had reduced (*P*<0.0001) ADG (0.96 ± 0.04 vs 0.75 ± 0.04 kg/d). In later finishing phases GHS pigs had greater LEA (P = 0.03; 40.13 ± 0.66 vs 38.15 ± 0.65 cm^2); and PAY increased LEA at slaughter (54.89 ± 1.06 vs 48.85 ± 1.04 cm^2). Carcass quality measures were recorded, and a chop was used to determine pork quality. PAY increased hot carcass weight (100.24 ± 1.19 vs 99.36 ± 1.18 kg, *P*=0.02); LEA (54.89 ± 1.05 vs 48.85 ± 1.04 cm^2, *P*<0.01); and pH (5.62 ± 0.02 vs 5.56 ± 0.01, *P*=0.01). PAY 110% barrows

had reduced 10th rib backfat (P=0.04) compared to CTL 110% barrows (20.16 ± 1.26 vs 23.94 ± 1.23). 110% PAY barrows had greater %LEAN compared to 100% CTL, 110% CTL, and 100% PAY barrows (54.61 ± 0.71 vs 52.16 ± 0.69, 51.48 ±0.69, and 52.51 ± 0.69 %, P<0.05). At slaughter, samples were collected from the longissimus dorsi (LD) and semitendonosus (ST) for ATPase assay. The number and size of primary and secondary muscle fibers were determined. GHS increased secondary fibers in LD (58.17±1.17 vs 60.90±1.06 µm; P=0.09) and ST (67.70±1.36 vs 72.74±1.40 µm; P=0.01). GHS interactions with PAY were also found. Heat stress during gestation altered muscle development, resulting in increased muscle fiber size at harvest and a tougher product. Rectal, ear, and rump temperatures and respiration rate (RR) were recorded twice weekly from 3 to 6 months of age for gilts (n=165). Room temperature ranged over time and time of day from 23.01°C-29.78°C (73.4-85.6°F). GHS pigs maintained body temperature with less effort, having lower RR (15.04±0.13 vs 15.83±0.15 breaths per min for GHS and GTN, respectively, P<0.001). Higher room temperatures at the time of measurement were associated with increased RR (12.28±0.49-19.62±0.49 breaths per min; P<0.001), though this did not differ by treatment. Gilts aged 193-198d were transported to Virginia Tech (TAREC). Estrus was recorded and synchronized to facilitate 68 litters born in four farrowing groups. GHS gilts tended to eat more during lactation (5.42±0.115 vs 5.12±0.114 kg/d; P=.07) with no effect on lactation weight loss. Numbers born, born alive or stillborn did not differ significantly by treatment, though numerically all favored GTN gilts (12.06±0.72 vs 12.94±0.72; 11.32±0.67 vs 11.76±0.67; 0.53±0.15 vs 0.47±0.15 for GHS vs GTN, respectively). GHS gilts tended to have lower piglet survival than GTN gilts (88.9±.02% vs 93.9±.02%; P=.08). A numerical non-significant difference of almost one piglet was observed favoring GTN gilts for total piglets weaned per litter (9.91±0.53 vs 10.85±0.53). The impact of heat stress on the swine industry has likely been underestimated using data on animals subjected to ambient temperatures outside of their thermoneutral zone. Preliminary data and data from other species suggest *in utero* environment could indeed have a significant effect on subsequent performance. This concept has not received due consideration, and in terms of thermal environment may help more accurately identify the value of cooling in gestation facilities. Being a fetus in a heat stressed dam appears to have negative impacts on feed efficiency and reproductive performance.

Key Findings:

- Differences between GHS and GTN piglets were not as large in this replicate as had been observed in previous replicates for body composition and temperature
- Differences did still exist, with GHS pigs eating more feed but not differing in weight gain or body composition.
- GHS pigs appear to be more active and spend more time at the feeder.
- While relatively small number of females were mated, reproductive differences between GHS and GTN gilts were largely non-significant but all favored the GHS gilts.

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Scientific Abstract:
Large White x Landrace gilts (Choice Genetics USA) were artificially inseminated and housed under thermoneutral (GTN; 18-22ºC) or heat stress (GHS; 28-34ºC) conditions throughout gestation, then lactated ~21d under TN conditions. At weaning, GHS and GTN gilts were housed together in pens of 22-25 gilts per pen. Barrows were double stocked here until approximately 25kg, then 80 barrows were individually housed

and fed in attempt to correct impact of *in utero* heat stress: a corn soybean meal diet that met (100%) or exceeded (110%) NRC lysine requirements; in the last 30 days barrows received a diet with 0 (CTL) or 7.4 ppm Paylean (PAY) until 121 kg. Weight, average daily gain (ADG), and feed disappearance (FD) were recorded. Week one weight was greater (*P*=0.03) in HS barrows (2183.00 ± 60.48 vs 1999.01 ± 59.66 g) but tended to be reduced (*P*=0.08) in HS barrows in late finishing (121.58±1.47 vs 125.26 ± 1.49 kg). In both grower (*P*=0.04) and finisher (*P*=0.05) phases, FD was greater in HS barrows (2.22 ± 0.05 vs 2.08 ± 0.05; 3.29 ± 0.08 vs 3.00 ± 0.08, respectively). PAY barrows had reduced (*P*<0.0001) ADG (0.96 ± 0.04 vs 0.75 ± 0.04 kg/d). In later finishing phases GHS pigs had greater LEA (P = 0.03; 40.13 ± 0.66 vs 38.15 ± 0.65 cm^2); and PAY increased LEA at slaughter (54.89 ± 1.06 vs 48.85 ± 1.04 cm^2). HS barrows had lower temperatures, which were increased by 110% lysine and PAY, indicating GHS barrows have the potential to maintain lower body temperatures and produce greater LEA at slaughter. Carcass quality measures were recorded, and a chop was used to determine pork quality measures. PAY increased HCW (100.24 ± 1.19 vs 99.36 ± 1.18 kg, *P*=0.02); LEA (54.89 ± 1.05 vs 48.85 ± 1.04 cm^2, *P*<0.01); pH (5.62 ± 0.02 vs 5.56 ± 0.01, *P*=0.01); and reduced b* (8.15 ± 0.19 vs 8.66 ± 0.18, *P*=0.05). PAY 110% barrows had reduced 10^{th} rib backfat (*P*=0.04) compared to CTL 110% barrows (20.16 ± 1.26 vs 23.94 ± 1.23). 110% PAY barrows had greater LEAN compared to 100% CTL, 110% CTL, and 100% PAY barrows (54.61 ± 0.71 vs 52.16 ± 0.69, 51.48 ±0.69, and 52.51 ± 0.69 %, *P*<0.05). At slaughter, samples were collected from the longissimus dorsi (LD) and semitendonosus (ST) for ATPase assay. The number and size of primary and secondary muscle fibers were determined. GHS increased secondary fibers in LD (58.17±1.17 vs 60.90±1.06 µm; *P*=0.09) and ST (67.70±1.36 vs 72.74±1.40 µm; *P*=0.01). GHS interactions with PAY were also found. There were positive correlations between shear force and LD primary (r=0.31, *P*=0.01) and secondary (r=0.27, *P*=0.04) and ST primary fibers (r=0.30, *P*=0.03). Heat stress during gestation altered muscle development, resulting in increased muscle fiber size at harvest and a tougher product. Rectal, ear, and rump temperatures and respiration rate (RR) were recorded twice weekly from 3 to 6 months of age for gilts (n=165). Room temperature ranged over time and time of day from 23.01°C-29.78°C. GHS pigs maintained body temperature with less effort, having lower RR (15.04±0.13 vs 15.83±0.15 breaths per min for GHS and GTN, respectively, P<0.001). Higher room temperatures at the time of measurement were associated with increased RR (12.28±0.49-19.62±0.49 breaths per min; P<0.001), though this did not differ by treatment. Gilts aged 193-198d were transported to Virginia Tech (TAREC). Estrus was recorded and synchronized to facilitate 68 litters born in four farrowing groups. GHS gilts tended to eat more during lactation (5.42±0.115 vs 5.12±0.114 kg/d; P=.07) with no effect on lactation weight loss. Numbers born, born alive or stillborn did not differ significantly by treatment, though numerically all favored GTN gilts (12.06±0.72 vs 12.94±0.72; 11.32±0.67 vs 11.76±0.67; 0.53±0.15 vs 0.47±0.15 for GHS vs GTN, respectively). GHS gilts tended to have lower piglet survival than GTN gilts (88.9±.02% vs 93.9±.02%; P=.08). A numerical non-significant difference of almost one piglet was observed favoring GTN gilts for total piglets weaned per litter (9.91±0.53 vs 10.85±0.53).

Introduction:

Producers recognize summer related heat stress results in reduced feed intake, growth rate and reproductive performance, and most research has been aimed at these direct responses. It has also been shown that heat stress can reduce birth weight and increase number of stillborn piglets. Piglets that survive need to be fed longer and never reach the potential of their normal or heavy birth weight littermates, leading to increased input costs and lighter market weights. Furthermore, light birth weight pigs have smaller muscle fibers and adipocytes leading to less tender products, affecting the amount of marbling. Subsequent reproductive performance of piglets developing under heat stress conditions has not been reported and may magnify the impact heat stress has on the U.S. swine industry.

Clearly heat stress impacts economically important traits. This proposal is designed to collect data on economically important traits of growth, body composition, carcass quality, fat quality, puberty and subsequent reproductive performance on piglets developing *in utero* under heat stress conditions.

Preliminary data and data from other species suggest *in utero* environment could indeed have a significant effect on subsequent performance. This concept has not received due consideration, and in terms of thermal environment may help more accurately identify the value of cooling in gestation facilities.

Project Objectives -

1. Define consequences of *in utero* heat stress on growth and body composition of barrows and gilts.

2. Determine consequences of *in utero* heat stress on carcass composition and pork quality in barrows with or without a typical Paylean feeding program.

3. Delineate a mechanism to alleviate the effects of heat stress during gestation on postnatal growth potential through feeding diets containing increased lysine and Paylean.

4. Characterize consequences of *in utero* heat stress on age at puberty and subsequent reproductive performance of gilts.

Materials & Methods:

First parity Large White x Landrace gilts (Choice Genetics USA) were artificially inseminated and housed under either cyclical thermoneutral (GTN; 18-22ºC) or heat stress (GHS; 28-34ºC) conditions throughout gestation at the University of Missouri (MU) Brody Environmental Chambers. Gilts farrowed in March 2013 and lactated for ~21d under TN conditions, after which piglets were weaned to a mechanically ventilated wean-finish barn at the MU South Farm and raised under commercial conditions.

Barrows

At 25 kg, barrows of control (TN; n=40) or heat stressed (HS; n=40) dams were individually housed and fed a corn soybean meal diet. At this time, barrows were equally and randomly assigned to receive a diet that met (100% NRC; n=20) or exceeded (110% NRC; n=20) NRC lysine requirements. In the last 30 days of finishing, barrows were again equally and randomly assigned to a diet containing 0 (CTL; n=10) or 7.4 ppm Paylean (PAY; n=10). Diets were fed until 121 kg of weight was attained, at which time all barrows were slaughtered at the University of Missouri abattoir. At slaughter, picnics from these barrows made into fresh ground pork patties and pork sausage patties. Patties were placed on Styrofoam trays, overwrapped with polyvinyl chloride and displayed under fluorescent lights for six days to determine oxidative color stability. Raw patties of each type were analyzed for objective color by Minolta Chromameter on days 0, 2, 4, and 6; oxymyoglobin concentrations on days 2 and 4; and TBA values on days 1 and 6. Hams from these barrows were deboned and knuckles were cured and smoked. Wet, pumped, and cooked weights, as well as brine uptake, were recorded for each ham. Cook loss and percent yield were calculated. Hams were sliced at a thickness of 2.5 cm, vacuum sealed for storage, and displayed under fluorescent lights for 120 days. Ham slices were analyzed on days 30, 60, 90, and 120 for objective color by Minolta Chromameter and TBARS measurements. A sensory panel consisting of consumers was conducted on day 30 for overall liking, tenderness, juiciness, and flavor using a measured line ballot, using a 10 cm line. Additionally, muscle samples were collected from the longissimus dorsi (LD) and semitendonosus (ST) and used for the ATPase assay. In the LD, the number of primary muscle fibers (PCLD), the number of secondary fibers (SCLD), the size of primary fibers (PDLD) and the size of secondary fibers (SDLD) were determined. The same variables (PCST, SCST, SPST, PDST, SDST) were determined for ST. The ratio of secondary to primary fibers (SPLD, SPST) was also determined for each LD and ST.

Gilts

Weaned gilts (n=165) were moved to the University of Missouri Swine Pasture Farm Finisher on 4/19/13 at 22-27 days of age. Gilts were originally stocked in one room, then divided between two rooms after 75d (7/03/13). Animals were housed 21-22 per pen, with pen size being doubled by removing the divider. Each pen had one self-feeder and one cup waterer. Pens were equipped with one 3x3 rubber mat and one heat lamps for the first 21 days, after which the mats and heat lamps were removed. Gilts were housed in the After 174 days gilts were shipped to the Tidewater Agricultural Research and Extension Center (TAREC) in Suffolk, Virginia on 10/07/13.

<u>Experimental Design</u>

The daily ambient temperature in the growing period was set on an automatic system and followed industry standards based on gilt age and time in barns. Each room was equipped with three fans that ran according to set temperature. Lights were controlled manually but were left on for at least eights hour per day. One set of lights (out of five) was left on 24 hours per day to encourage full feeding behavior. Finisher room temperature varied between 23.01-29.78C.

<u>Body Weights</u>

While at the Animal Sciences Research Center, gilts were weighed at birth, two hours after birth, 24 hours after birth, and weekly until weaning using a tabletop digital scale. Once in the Pasture Farm Finisher, gilt weights were recorded every three weeks using a standard heavy duty single animal crate scale with an electronic load cell.

<u>Thermal Measurements</u>

In the Finisher, thermal response measurements were taken two times per week, twice daily at 0600 and 1400 hours or once per week, one time per day at 1400 hours. Rectal temperatures were measured with an over the counter basal thermometer. Respiration rate was calculated by counting breaths per minute. Skin temperature measurements were taken at two locations (ear and rump) using an infrared temperature gun.

<u>Heat Checking Management</u>

Starting at 144-149 days of age (8/19/13), gilts were exposed to a boar daily for 15 minutes per pen. During exposure gilts were given a vulva score ranging from 0 to 3, with 0 being no signs of heat and 3 being standing heat. After 40 days (9/28/13) any gilts not having shown standing heat were given a dose of PG600® and boar exposure continued for 9 more days until gilts were shipped to Suffolk, Virginia on 10/07/13 (193-198d of age). Here, gilts were group housed in naturally ventilated partially slatted gestation facilities. Estrus was recorded and synchronized to facilitate 68 litters born in four farrowing groups. Farrowing was in conventional farrowing crates with partially slatted floors under the sow, heat lamps for piglets, and sows on *ad libitum* feeding. Data were analyzed using ANOVA including treatment, season (March and April vs July and September) and their interaction where appropriate.

VIII. Results:

1. Define consequences of *in utero* heat stress on growth and body composition of barrows and gilts:

Pigs in this study were from the fourth replicate of a sow heat stress project. All piglets from the first three replicates were weaned to Iowa State University. Analyses there consistently demonstrate GHS pigs differ from

GTN pigs, typically having a higher rectal temperature and being fatter. While statistical power was similar for this replicate, those carcass composition differences were not exhibited in these pigs (Table 1). Experimentally they were housed at different facilities. Genetically they also differed, being maternal line crosses rather than having a Duroc sire. Neither of these provides clear explanation of why body composition differences were not observed in these pigs. Effects of Paylean were as anticipated and they did not interact with treatment. It is curious that although GHS and GTN barrows grew at similar rates, feed disappearance differed both early and late in the growing phase (Figure 1).

Table 1 P values for carcass traits

Effect	Loineye area	10^{th} rib fat	Last rib fat	Dressing %
Treatment	0.196	0.892	0.223	0.708
Lysine level	0.365	0.515	0.830	0.633
Ractopamine	<0.001[1]	0.089[3]	0.419	0.033
Trtmt x Lys	0.588	0.313	0.245	0.911
Trtmt x Rac	0.896	0.779	0.262	0.180
Slaughter weight	0.065[2]	0.001[4]	0.015[4]	0.002[5]

[1]Ractopamine resulted in larger loineye area (49.02 vs 54.65 cm^2)

[2]within the range of slaughterweights heavier barrows tended to have larger loineye area

[3]Ractopamine resulted in less tenth rib backfat (23.66 vs 21.60 mm)

[4]within the range of slaughterweights heavier barrows had greater backfat thickness at both locations

[5]dressing percentage was lower for heavier barrows

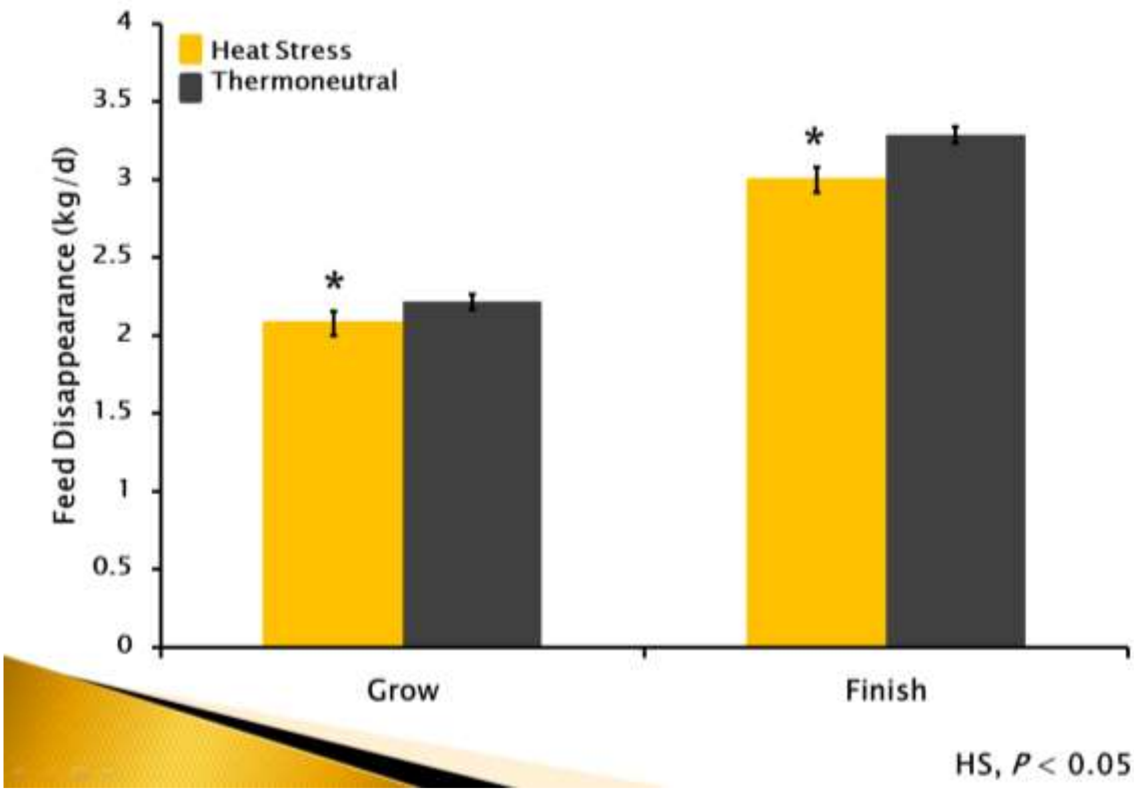

Figure 1. Average daily feed disappearance in individually housed gestationally heat stressed or thermoneutral barrows for the grower and finisher phase of production.

HS treatment increased (58.17±1.17 vs 60.90±1.06 µm; *P*=0.09) SDLD. HS by PAY interactions were found for SDLD (*P* = 0.02) and SPLD (*P* = 0.04). There was a trend for an interaction between lysine by HS for SCLD (*P* = 0.08). HS by lysine by PAY interactions existed for SCLD (*P* = 0.03) and SPLD (*P* = 0.009). In ST muscle, HS treatment increased PDST (57.74±1.09 vs 63.78±1.13 µm; *P*=0.0003) and SDST (67.70±1.36 vs 72.74±1.40 µm; *P*=0.01). Trends for HS by PAY interactions existed for PCST (*P*=0.08) and SPST (*P*=0.09). A lysine by PAY interactions was found for PDST (*P*=0.04), trends for this interactions were also found in PCST (*P*=0.07) and SCST (*P*=0.10). There were also positive correlations between shear force and PDLD (r=0.31, *P*=0.01), SDLD (r=0.27, *P*=0.04) and PDST (r=0.30, *P*=0.03) and a tendency for SDST (r=0.25, *P*=0.06). Heat stress during gestation alters muscle development, resulting in increased muscle fiber size at harvest and ultimately a tougher product.

As described earlier, gilts were housed in separate rooms from barrows from weaning and subjected to different management and measurements. Temperatures were similar for GHS and GTN pigs overall (39.11°C, 35.61°C and 35.56°C for rectal, ear and rump temperatures, respectively). Increasing respiration rate is one of the major mechanisms used by pigs to regulate temperature, and it appears GHS pigs were able to maintain the body temperature with less effort, having lower RR (15.04±0.13 vs 15.83±0.15 breaths per min for GHS and GTN, respectively, P<0.001). Higher room temperatures at the time of measurement were associated with increased RR (range 12.28±0.49-19.62±0.49 breaths per min; P<0.001), though this did not differ by treatment. Because groups were housed together it was not possible to measure feed disappearance in gilts. Behavioral observations would suggest GHS gilts ate more, and certainly did spend more time at the feeders (Figure 2), though similar to their brothers did not grow differently over this period by treatment (Figure 3).

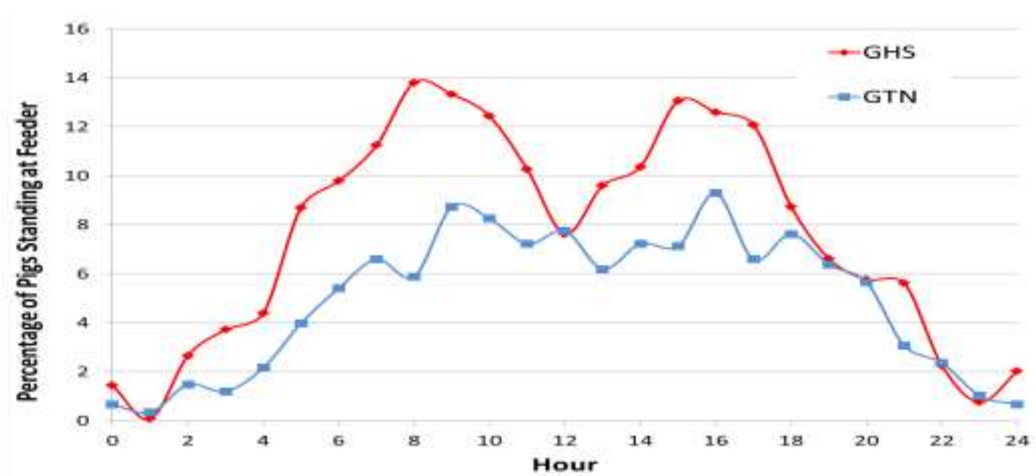

Figure 2. Percentage of time per 24 hour period that growing gilts spent standing by the feeder by gestational treatment (heat stressed (GHS) or thermoneutral (GTN).

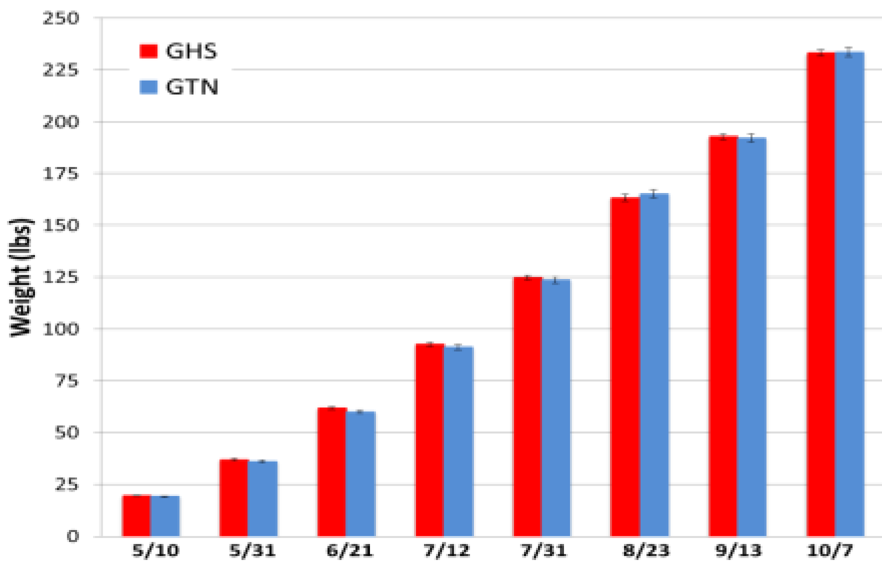

Figure 3. Gilts from gestationally heat stressed (GHS) or thermoneutral (GTN) environments did not grow differently over the grower-finisher phase.

Objectives 2. Determine consequences of *in utero* heat stress on carcass composition and pork quality in barrows with or without a typical Paylean feeding program and 3. Delineate a mechanism to alleviate the effects of heat stress during gestation on postnatal growth potential through feeding diets containing increased lysine and Paylean:

The hypothesis was that repartitioning agents (e.g. Paylean) and differential feeding strategies (e.g. varying lysine levels) would allow the negative consequences of *in utero* heat stress to be alleviated. It was striking that we were unable to demonstrate impacts of gestational heat stress on growth or composition in the present study. Tables 2 and 3 present P values for the various carcass level and consumer level meat quality traits. There tended to be an interaction between treatment and lysine levels for cooking loss (Table 3), implying gestational heat stress environment differentially affected the ability to metabolize lysine and, therefore, higher lysine affected water loss at cooking differentially. A biological explanation for such a phenomenon is not offered.

Table 2. P values for carcass level meat quality traits

Effect	L*	a*	b*	pH
Treatment	0.948	0.818	0.364	0.348
Lysine level	0.303	0.324	0.526	0.391
Ractopamine	0.274	0.741	0.057[1]	0.011[2]
Trtmt x Lys	0.443	0.953	0.911	0.525
Trtmt x Rac	0.290	0.902	0.408	0.695

[1]Ractopamine tended to make b* lower (8.66 vs 8.15)

[2]Ractopamine treated barrows had higher pH (5.56 vs 5.62)

Table 3. P values for consumer level meat quality traits

Effect	Cooking loss	Shear force
Treatment	0.147	0.436
Lysine level	0.925	0.855
Ractopamine	0.453	0.001[2]
Trtmt x Lys	0.054[1]	0.271
Trtmt x Rac	0.568	0.974

[1]Cooking loss was numerically lower for thermoneutral gestated barrows fed high lysine (21.6 vs 23.4%) and higherer for gestationally heat stressed to barrows fed high lysine (24.8 vs 22.9%) resulting in a tendency for a treatment x lysine level interaction

[2]Ractopamine treated barrows had higher shear force (3.94 vs 4.73 kg), though still in the tender range

Preliminary data had also suggested fatty acid profiles could vary depending on *in utero* environment. While some statistically significant differences were found, they were mostly not significant, and no biologically meaningful pattern was observed for either belly fat or jowl fat and there were no tendencies for interactions with ractopamine or lysine level (Table 4 and 5). In the rare cases where statistically significant differences were detected both treatment groups were still well within what would be considered normal acceptable standards for pork quality.

Growth hormone, IGF-1 and leptin were measured in barrows at multiple time points and at slaughter. No treatment effects were detected for any of the hormone levels. That result was surprising, and currently no explanation is offered for the lack of detection of treatment effect, and further analyses of the blood parameters are planned.

Table 4. P values for fatty acids in belly fat

Effect	16:0	16:1	18:0	18:1n9c	18:2n6	18:3n6	20:4
Treatment	0.901	0.244	0.185	0.398	0.327	0.064[1]	0.306
Lysine level	0.193	0.761	0.173	0.296	0.607	0.411	0.417
Ractopamine	0.642	0.632	0.404	0.174	0.758	0.663	0.983
Trtmt x Lys	0.318	0.248	0.091[2]	0.929	0.424	0.511	1.000
Trtmt x Rac	0.889	0.940	0.201	0.245	0.338	0.226	0.429

[1]Barrows gestationally heat stressed (GHS) tended to have lower levels (0.363 vs 0.393).

[2]GHS barrows fed 110% required levels of lysine tended to have reduced levels compared to htose fed at the required level (10.47 ± 0.20 vs 9.85 ± 0.21) while gestationally thermoneutral barrows were not affected (10.40 ± 0.20 vs 10.47 ± 0.20)

Table 5. P values for fatty acids in jowl fat

Effect	16:0	16:1	18:0	18:1n9c	18:2n6	18:3n6	20:4
Treatment	0.526	0.176	0.714	0.640	0.167	0.485	0.008[1]
Lysine level	0.900	0.953	0.861	0.734	0.393	0.476	0.318
Ractopamine	0.191	0.821	0.529	0.886	0.271	0.932	0.036[2]
Trtmt x Lys	0.352	0.305	0.814	0.490	0.966	0.570	0.124
Trtmt x Rac	0.501	0.813	0.637	0.919	0.233	0.576	0.253

[1]Barrows gestationally heat stressed had higher levels (0.221 ± 0.009 vs 0.184 ± 0.010).

[2]Ractopamine feeding resulted in higher levels (0.217 ± 0.009 vs 0.196 ± 0.010).

4. Characterize consequences of *in utero* heat stress on age at puberty and subsequent reproductive performance of gilts.

The percentage of gilts responding to the boar exposure was strikingly low across both treatments. The intended boar became lame immediately prior to initiation of detection of estrus, so younger boars were used. Even in the absence of a boar effect we were surprised that only six of 123 gilts reached puberty between 150-190 days of age. The remaining 117 gilts were treated with PG-600, and 81 responded with estrus within 5d, and response did not differ by treatment.

Gilts were managed together at TAREC, and though anticipated seasonal effects were seen, neither treatment nor treatment x season interaction affected breeding weight, gestation weight gain, nor gestation length (Table 5). All were fed *ad libitum* with twice daily hand feeding.
GHS gilts tended to eat more during lactation (5.42±0.115 vs 5.12±0.114 kg/d; P=.07) with no effect on lactation weight loss.

Table 5. Production measures for gilts having developed under gestational heat stress (GHS) or thermoneutral (GTN) environments.

	GHS	**GTN**
Gestation length, d	115.0 ±.25	114.8 ±.21
Weight at breeding (lbs)	353.26 ± 6.90	353.73 ± 6.69
Gestation weight gain (lbs)	105.46 ± 9.54	101.69 ± 6.40
Lactation weight loss (lbs)	49.99 ± 7.50	41.87 ± 7.54
Lactation feed intake[1] (lbs)	11.95 ± 0.25	11.31 ± 0.26

[1]This 5% difference approached statistical significance (P=0.07).

Prior to farrowing the fourth group data were analyzed for a preliminary report, and litter parameters were significantly different favoring GTN gilts. The patter in the fourth farrowing group was different from the first three and resulted in any differences becoming numerical rather than statistical. Though numbers born, born alive or stillborn did not differ significantly by treatment, numerically all favored GTN gilts (12.06±0.72 vs 12.94±0.72; 11.32±0.67 vs 11.76±0.67; 0.53±0.15 vs 0.47±0.15 for GHS vs GTN, respectively and Figure 4). GHS gilts tended to have lower piglet survival than GTN gilts (88.9±.02% vs 93.9±.02%; P=.08). A numerical non-significant difference of almost one piglet was observed favoring GTN gilts for total piglets weaned per litter (9.91±0.53 vs 10.85±0.53). Further research is needed to quantify reproductive status of gilts developing *in utero* under heat stress conditions.

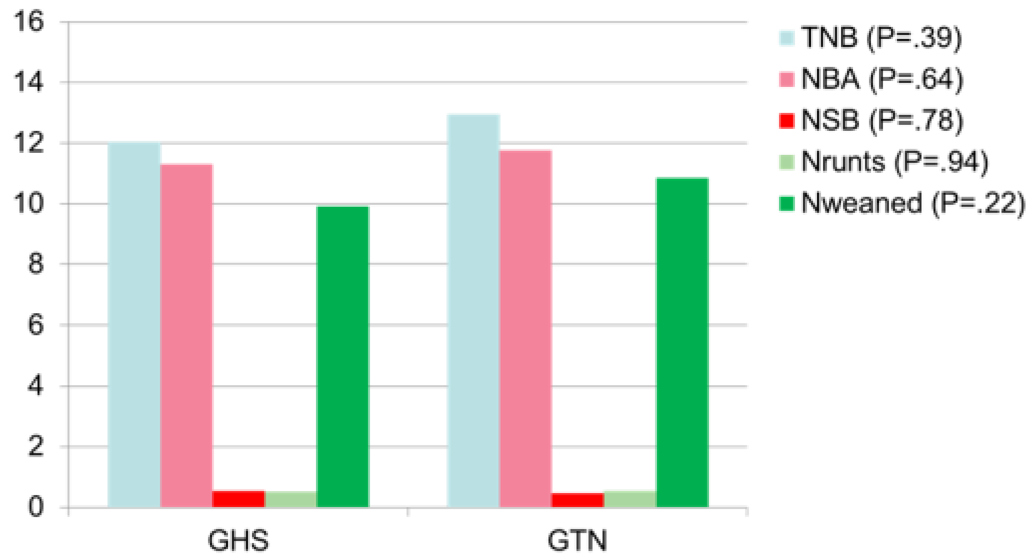

Figure 4. Litter parameters (total number born, number born alive, number stillborn, number of runts and number weaned, respectively) for gilts gestated under heat stress (GHS) or thermoneutral (GTN) conditions.

Discussion:
There is not a clear explanation for why barrows GHS or GTN differed so little in this experiment. While genetically they were a maternal line cross rather than a terminal x maternal cross, that does not offer an explanation for why gestational treatment would not have been detectable. Differences in barrows did exist, with GHS barrows having higher feed intake and similar body weight gain and composition. For female productivity traits, any differences observed also favored the GTN gilts both growing (where they appeared to be similar to barrows) and as parity one females (tendency for reduced productivity across most traits though not statistically different). Heat stress is known to result in significant production losses to the swine industry in terms of delayed puberty, irregular estrous cycles, increased incidence of abortion and stillborn pigs on the breeding herd side and reduced feed intake and growth/composition of growth on the growing pig side. Taken together these data suggest the true cost to the industry of heat stress is likely significantly underestimated, having not accounted for the impact of *in utero* heat stress on subsequent performance.