EFFECT OF HEAT STRESS ON LYING TIME IN TIE-STALL HOLSTEIN DAIRY COWS

By

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Abstract

As temperatures around the globe increase and the demand for dairy products increase, heat stress management has become a priority in dairy herd management. Since the majority of dairies in the U.S. are open dry lots with a barn or shed, little research has been done on tiestall dairies and how heat stress effects cows in such operations. In this study, I attempted to document how multiparous lactating Holsteins responded to heat stress in terms of changes in lying time. The results were not statistically significant, with the average lying time during the thermoneutral period being 8.1 $\pm$ 3.004 hours and 8.7 $\pm$ 4.032 hours during the heat stress period. Finally, during the recovery period was 11.5 $\pm$ 5.807 hours. More precise measurement techniques would help in further research.

Acknowledgements

I would like to thank my advisor Dr. Duarte Diaz, for allowing me to participate in this project. I would also like to thank Matthew Vander Poel for letting me work on a project that is a part of his thesis research. Thank you to my friends and family for their support, and to the cows that were used in this study- the results from them will benefit dairy cows everywhere.

Introduction: As the world's population increases and global demands for animal products increase, the need for efficient food production increases as well. At the same time, as global temperatures rise, efficient animal production becomes more difficult. As both of these factors become more and more of a reality, heat stress has fast become an important area of research. Heat stress is defined as "…the sum of external forces acting on an animal that causes an increase in body temperature and evokes a physiological response" (Polsky and von Keyserlingk, 2017). When an animal is heat stressed, many changes in physiology can occur. For example, the animal will often eat less, because a lot of heat is produced during digestion and rumination (Hutjens, 2008). A heat stressed dairy cow also has an increased respiration rate which can lead to a decrease in carbonic acid in the blood, leading to acidification of the blood and subsequently tissues (Das et al., 2016). These effects are already difficult to manage in production animals, but the issues are compounded in lactating dairy cows. Heat stress causes a decrease in milk production, and the percentage of particular components such protein and milk fat (Das et al., 2016; Polsky and von Keyserlingk, 2017). A lactating dairy cow is already in a negative-energy balance due to the demands placed on her body by fetus development and high production lactation. This alone leads to a decrease in body condition score and body weight, which further complicates the situation (Das et al., 2016). Another issue is that heat stressed cows don't "breed back" as well, meaning they don't get pregnant again when in a timely manner. This is due to several factors, the first being that heat stressed cows don't display as many of the signs of estrus. Since ranchers generally rely on behavioral signs for detecting when to breed the cows, it is difficult to breed the cows efficiently. In general, heat stressed cows

have lower conception rates, decreasing efficiency (Das et al., 2016). Finally, heat stress often changes in time spent standing, which may be correlated with an increased incidence in lameness (Charlton et al., 2016).

In the U.S., the majority of dairy operations are open/dry lot with a barn/shed, while only 18.2% are tiestall or stanchion housing (United States Department of Agriculture, 2016). Since these are mostly very small to medium producers (>30 cows to 499 cows), not much research is being devoted to these types of facilities and how they handle heat stress and abatement. There are some unique features that effect tiestall dairies. Tiestall dairies have more of an opportunity to regulate temperature, however there are other variables that effect lying time, particularly in tiestalls, such as stall design. This study aimed to add to the body of knowledge on behavioral effects on lactating dairy cows in heat stress in tiestall conditions. My hypothesis was that as the cows were put into heat stress conditions they would spend more time standing.

Methods: Twelve multiparous lactating Holstein cows were obtained from a dairy in Stanfield, AZ. On average, they were 111.9 ± 16.80 Days in Milk (DIM) and producing an average of 74.25 ± 7.36 pounds of milk daily (Vander Poel et al.,). The cows were used in a feed additive study meant to lessen the effects of heat stress on production. The cows were randomly separated into two groups housed in separate rooms inside the Agricultural Research Center at the University of Arizona Campus Agricultural Center. They were put in tie-stalls with the dimensions 65 inches in length, 52 ¼ inches in width, and 47 ⅝ inches in height. The back of the stall had a single chain across and the floor was padded with a water bed that filled the space outlined by the fencing. Cow

4 had a waterbed until day 2 of the study when it broke and was replaced with industrial foam mats (see Figure 1 for setup).

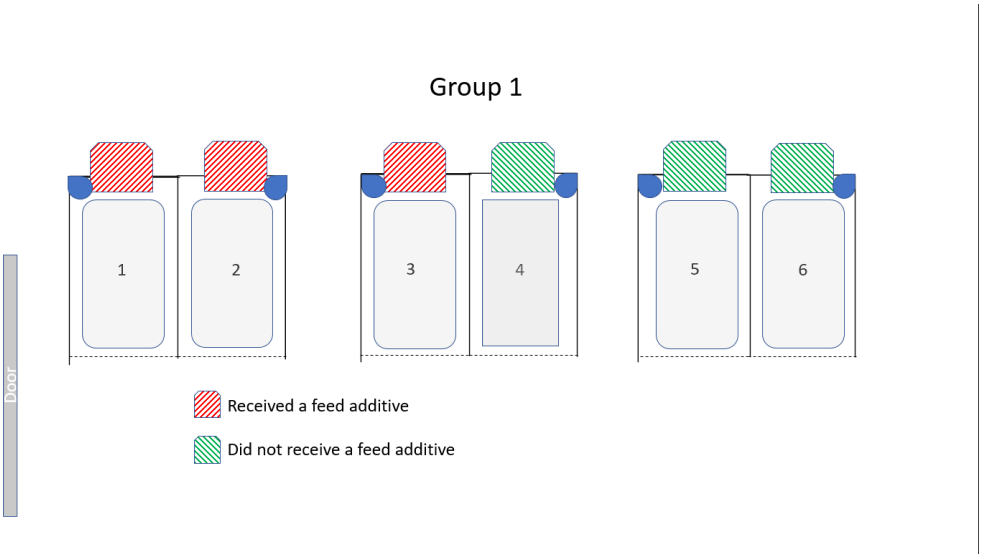

Figure 1 How the cows were housed, cow 4 had a different bedding type

Their temperatures were taken daily at peak temperature. The lights were set to come on at 5:00 and turn off at 19:00. They were milked at 5:00 and 17:00 in group 1 and 5:30 and 17:30 in group 2 in the morning and afternoon in their stalls with a portable milking unit The cows were fed a Total Mixed Ration (TMR), at 6:00 am in the morning, and around 6:00pm at night. Before the study began, the non-control cows were fed the additive for 14 days before the study began. The rooms were cleaned around the time they were being fed, until as late as 7am. The cows stayed mostly dry, the hoses were aimed at the ground and so the cows weren't cooled evaporatively. The cows had free access to water via a dish with a depressor that would fill the bowl. The study began on November 23rd, 2018 at 12:01 am and for the next four days the cows were kept at thermoneutral (Temperature Humidity Index (THI) 65.54-66.16) as they acclimated to the new environment. The cows were fitted with HOBO Pendant ® G Data Loggers on

the same day at 9am. The trackers were placed in double bagged plastic sandwich bags that were labeled with the cow's number, sealed, and then secured to the cow by placing the bagged tracker against the cow and wrapping the leg with vet wrap to hold it in place (see Figure 2).

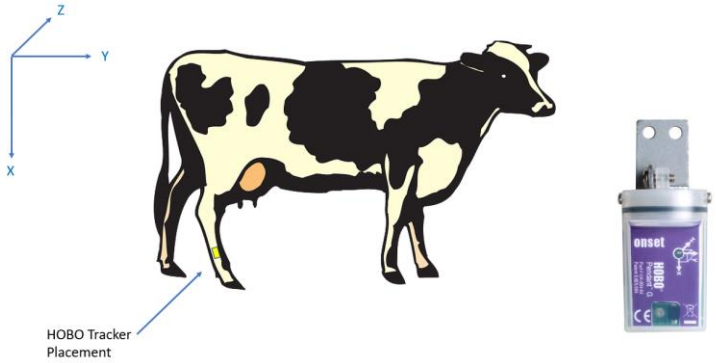

Figure 2 Placement of the Hobo Tracker and the consequent orientation of the axes

The trackers were removed to backup the data collected up to that point on day 9 of the study at 22 On day 4 of the study half the cows had muscle biopsies taken and IV catheters placed and the rest of the cows had the same on the day 5 of the study. For this reason, this day was excluded from the average lying time data because they had to go to a different room for this. Cow 11 was withdrawn and humanely euthanized at this point due to continuous poor health despite treatment efforts. A necropsy diagnosed her with hardware disease. The cows were subjected to heat stress beginning on day 8 at 00:01. The temperature and humidity were on a diurnal scale that had a THI range of 70.68-80.70 (See Figure 6 in the appendix for how the THI changed throughout the day). The heat stress period lasted for 7 days and ended day 14 at 00:01. The room was reset to thermoneutral and this lasted for 4 days, at the study ended on day 18.

The data was analyzed by comparing times in which the cows had specifically been observed to by lying down to the X acceleration data output from the loggers at that time (outputs at the end of the appendix, red line marks when the tracker was removed) similar to the method used in a study verifying that the tracker could be used for lying time detection in dairy cattle and calves(- *Technical note:* evaluation of data loggers for measuring lying behavior in dairy calves.; - Evaluation of data loggers, sampling intervals, and editing techniques for measuring the lying behavior of dairy cattle.). This determined the threshold for what qualified as a lying event for each of the cows. The loggers were taken off and the data was downloaded on day 9 and then the same logger was replaced on the same cows. That day was excluded, as well as any other days where the cows were handled beyond the usual milking and feeding or moved to another room for a procedure for another study.

Results:

In the thermoneutral portion of the study, the average temperature for the selected cows was 100.5 $\pm$ 0.864 degrees Fahrenheit. Under heat stress conditions, the average temperature for those cows was 103.2 $\pm$ 1.150 degrees Fahrenheit. Finally during the recovery period the rectal temperatures averaged 101.4 $\pm$ 0.663 degrees Fahrenheit. The daily temperatures are displayed in Figure 3.

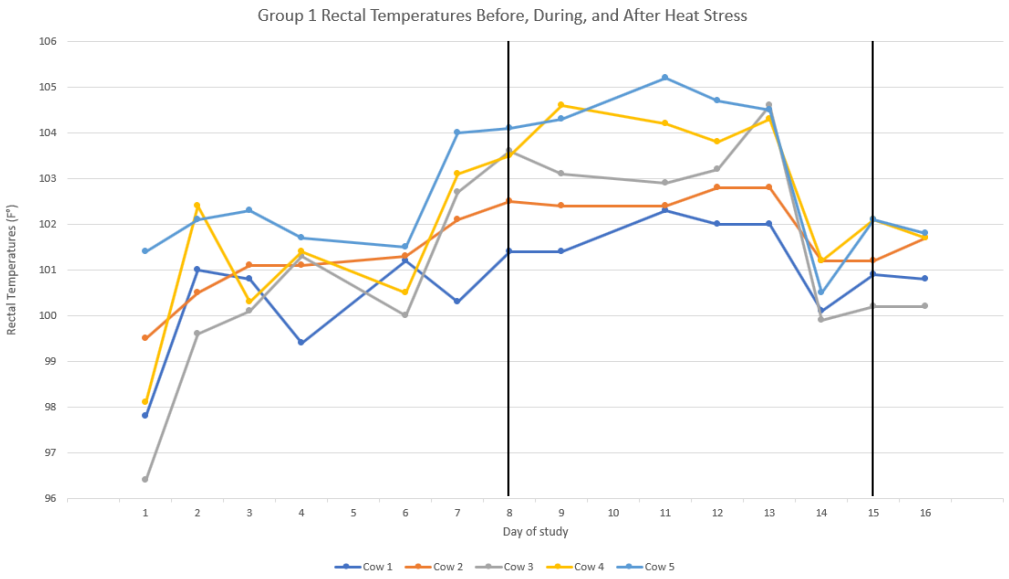

Figure 3 The graph is divided into the thermoneutral period, heat stress period, and recovery period, respectively. As heat stress begins, all of the cows' rectal temperatures increase.

There were two days on which rectal temperatures were not obtained, on the 5th and 10th days of the study.

Usable data was obtained through cows 1-5, and there were confirmed lying events as well. During the thermoneutral period, the average standing time was 15.9 $\pm$ 3.004 hours, and the average lying time was 8.1 $\pm$ 3.004 hours. During the heat stress period, the average standing time was 15.3 $\pm$ 4.032 hours, and the average lying time was 8.7 $\pm$ 4.032 hours. Finally, during the recovery period, standing time was on average 12.5 $\pm$ 5.807 hours, and lying time was 11.5 $\pm$ 5.807 hours. Figures 4 and 5 breakdown the individual hours for each period, for each cow with Tables 1 and 2 in the appendix giving all the individual values.

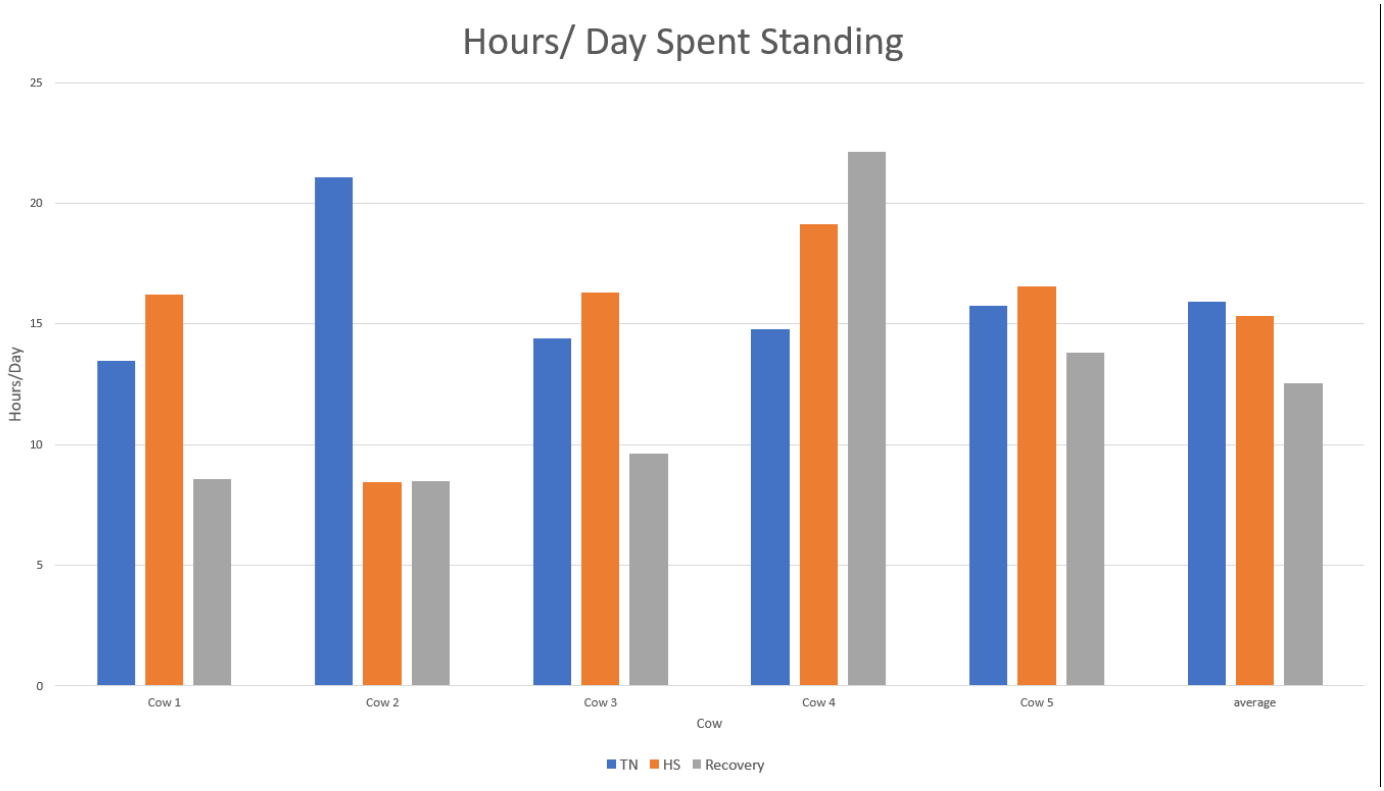

Figure 4 This graph shows the Hours/Day each cow spent standing in each of the period, with the average values for each period as the last data set on the right.

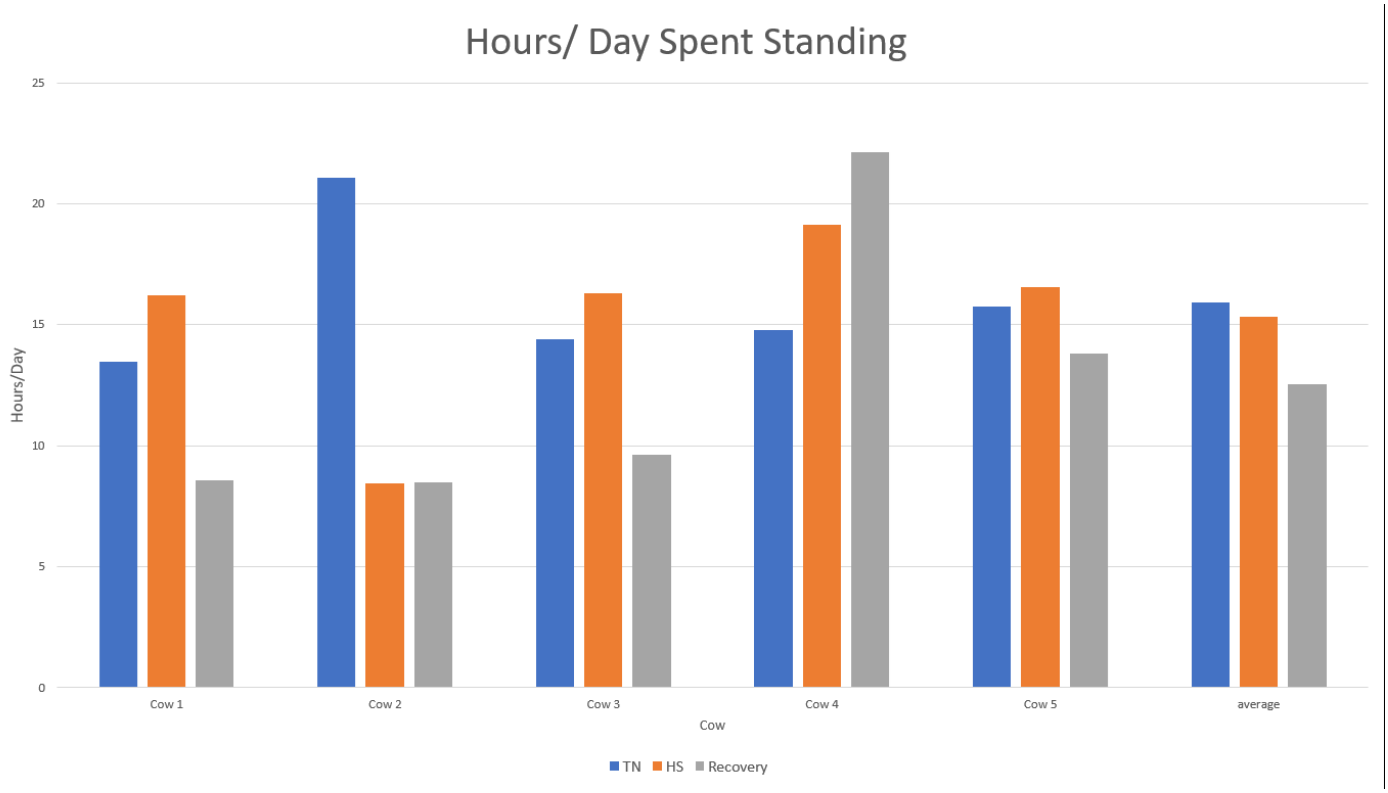

Figure 5 This graph shows the Hours/Day each cow spent lyinging in each of the period, with the average values for each period as the last data set on the right.

Discussion:

My hypothesis was that during the heat stress period, a decrease in lying time would be observed. However, the results were not significantly significant. The most likely reason for this was that in order to get the threshold that determined what qualified for “lying”, I had to physically observe the cows lying down and write down the time and date so that later I could cross-reference it to the data output from the logger. Since I took the tracker off once and then put it back on, I needed to obtain thresholds for both before and after that event in case there was any change in positioning that would change the results. For some of the cows, I had points for before and not after and so their data could not be used. For those that were usable (cows 1-5), I had at least one lying event in each data collection period. However, I think more points were necessary

because when those points were compared to the graph outputs from the loggers, the thresholds often did not encompass all the possible lying events. This is most likely why the hours spent lying for cow 2 in the thermoneutral period and cow 4 in the recovery period appear so low. However, cow 4 may be expected to have lower amounts of lying time as she had a different bedding material than the others.

Further research should be put into how stall design effects lying time during heat stress. As tiestall cows cannot move to a different microclimate in a yard or freestall set up, more research should be done looking into the microclimates surrounding them in a barn and how barn design can abate heat stress.

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Appendix

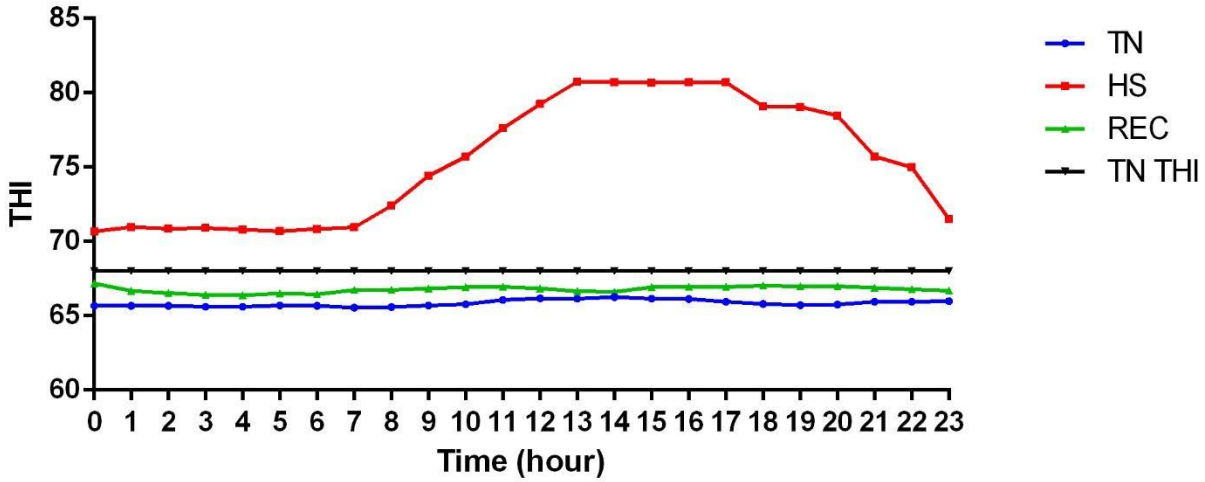


Figure 6 Shown is how the THI changed throughout the day for each of the test periods. Borrowed with permission from the thesis of Matthew Vander Poel (Vander Poel et al.,).

Hours Standing Up In Each Period

	Hours Standing During Thermoneutral Period	Hours Standing During Heat Stress Period	Hours Standing During Recovery Period
Cow 1	13.49	16.21	8.55
Cow 2	21.07	8.44	8.49
Cow 3	14.39	16.32	9.61
Cow 4	14.78	19.11	22.15
Cow 5	15.77	16.56	13.82
Average	15.9	15.33	12.52

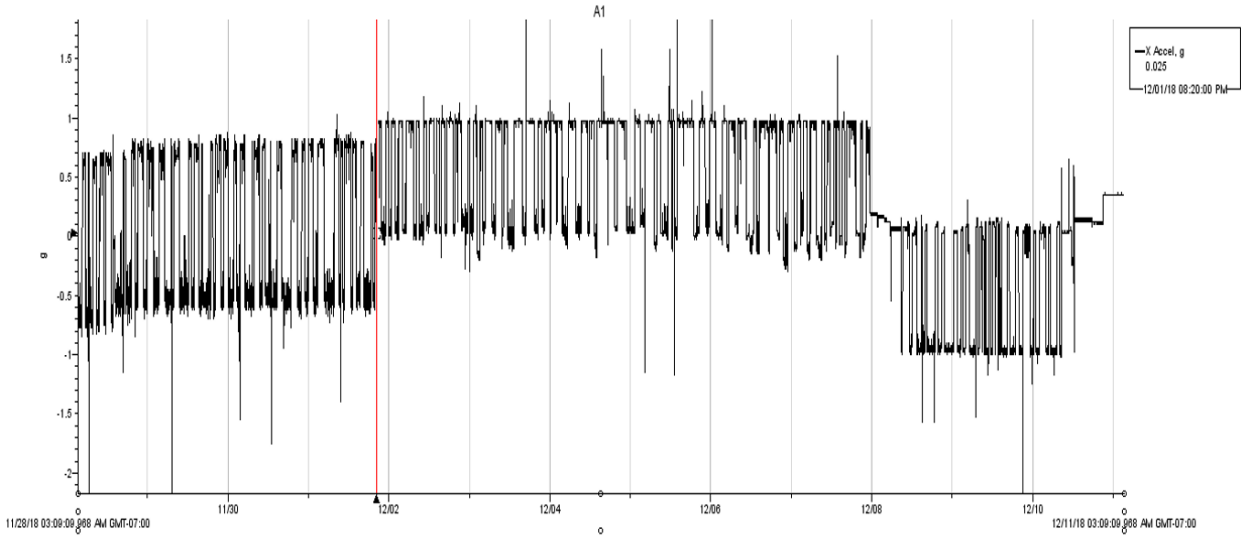
Table 1 Hours/ Day Spent Standing During Each Period

Hours Lying Down In Each Period

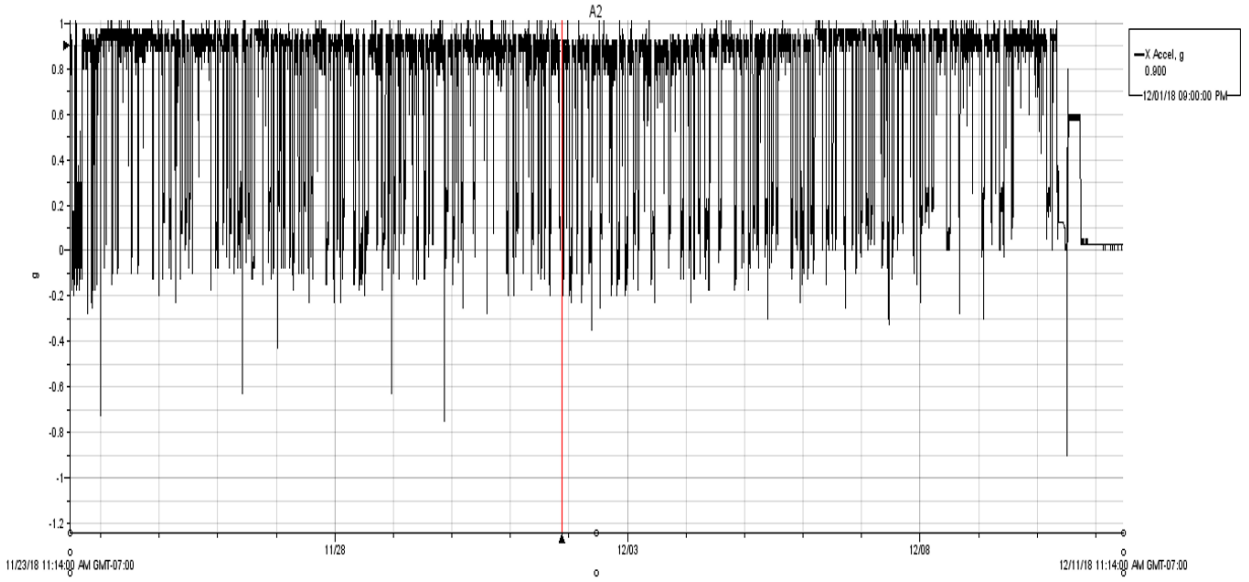
	Hours Lying During Thermoneutral Period	Hours Lying During Heat Stress Period	Hours Lying During Recovery Period
Cow 1	10.51	7.79	15.45
Cow 2	2.93	15.56	15.51
Cow 3	9.61	7.68	14.39
Cow 4	9.22	4.89	1.85
Cow 5	8.23	7.44	10.19
Average	8.1	8.672	11.478

Table 2 Hours/ Day Spent Lying During Each Period

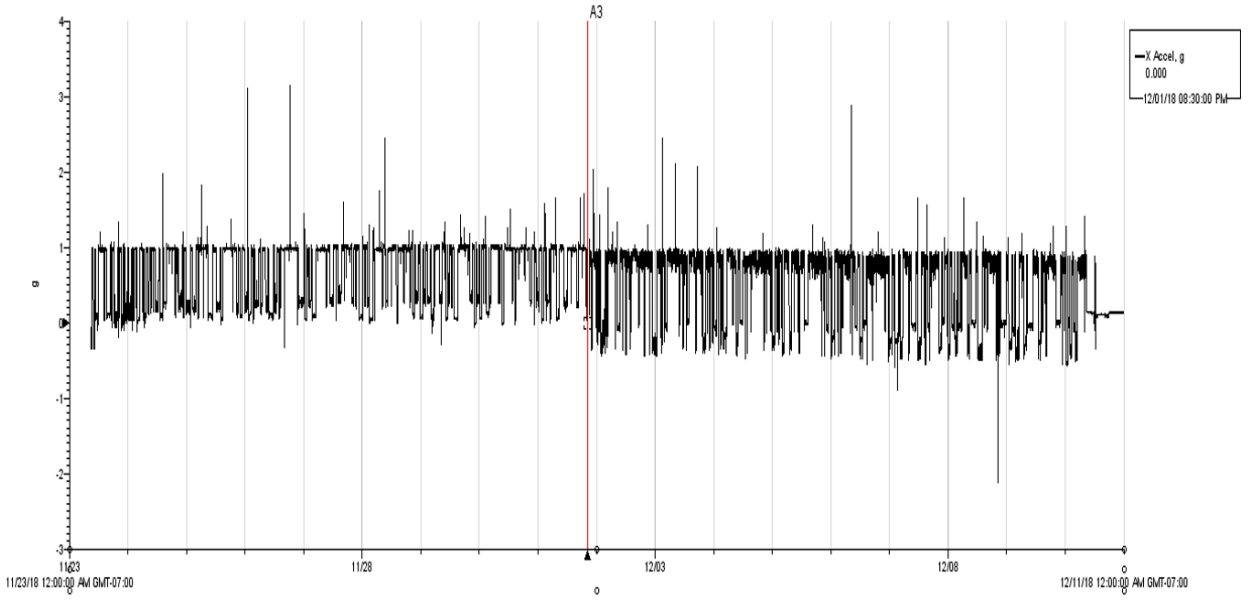
Cow 1 Hobo Logger Output



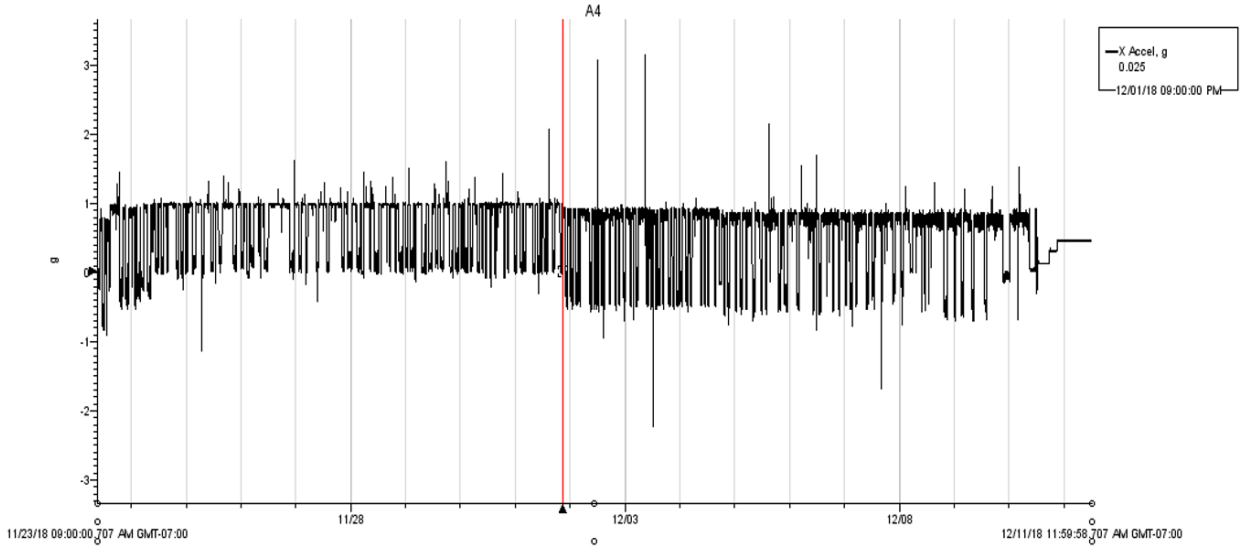
Cow 2 Hobo Logger Output



Cow 3 Hobo Logger Output



Cow 4 Hobo Logger Output



Cow 5 Hobo Logger Output