Uses of an Ear Tag Based Behavioral and Temperature Monitoring System (Cow Manager^{R}) at the ISU Dairy

A.S. Leaflet R3165

German Corujo, Animal Science Graduate Student;
Dr. Leo Timms, Morrill Professor in Animal Science

Summary and Implications

Animal movement monitors have been researched since the 1990's. The advent of accelerometer technology into these monitors coupled with wireless technologies to transmit data, and finally sophisticated algorithms and software to transcribe data to graphical and easy to use decision tools on animal behavior has resulted in many recent behavioral monitor systems becoming commercially available for animals and people. For dairy, many of the systems are neck based on collars, but a recent one has incorporated the accelerometer into an eartag that also has a temperature sensor. At Iowa State University, 36 animals were fitted with an ear tag based behavior and temperature monitor (Cow Manager, Agis Automatisering, Netherlands) to evaluate behavior and ear temperature change and learn the system. Tags were put on breeding age heifers, lactating cows, and transition cows. 34 other tags were acquired and put on transition cows. The system has served multiple purposes at the ISU Dairy. These include monitoring of animals and the herd from a commercial herd standpoint; teaching tool to introduce and embed undergraduate, graduate, and veterinary students in the technology (7 classes to date); a platform for 5 undergraduate independent studies to date; and utilized in 5 research projects to date including heat stress, calving behavior, LPS challenge model, calves, and evaluating animals as they adjust to Calan gate feeders. The system has also been a platform for extension presentations both at the ISU Dairy as well as many extension meetings and invited conferences and presentations. The behavior monitoring system has resulted in an excellent herd monitoring and decision system, as well as a teaching, research, and extension tool. The purpose of this report is to discuss these uses and give some examples of the systems output on behavior and temperatures and decisions associated or implemented as a result of that information.

Introduction

Animal movement monitors have been researched since the 1990's. The advent of accelerometer technology into these monitors coupled with wireless technologies to transmit data, and finally sophisticated algorithms and software to transcribe data to graphical and easy to use decision tools on animal behavior has resulted in many recent behavioral monitor systems becoming commercially available for animals and people. The objective of this work were to install an ear tag based behavior and temperature monitoring system and evaluate and utilize as a herd management tool as well as a teaching, research, and extension / outreach asset.

Materials and Methods

Animals and behavior tags: Initially, 36 behavior tags (left ears of cows and heifers) and 4 routers (3 for in barn and one at the computer) were installed. Wireless routers were installed in the lactating cow barn, west end of maternity barn near the transition barn, and pregnant heifer barn (near breeding heifer barn). Initially16 tags were put on 4 animals each in 4 lactating cow pens, 8 tags were put on breeding age heifers, and 12 tags were put on transition cows 1 month before calving (9 cows and 3 heifers) for 3 months to look at different animals and aspects of the behavior monitoring system, as well as understand and learn the system. An additional 34 tags were acquired and put on transition cows. Following this initial period, tags were either put on transition cows 1 month prior to calving through 200 days in milk, or in student independent study projects, or research trials as needed or asked for. The pregnant heifer barn router was moved to the transition barn also.

Behavior monitoring system: A graphical representation of the Cow Manager Behavior Monitoring system is shown in Figure 1. The system consisted of ear tag sensors (SensOor: accelerometers and temperature sensor) that were activated by rubbing a magnet against them before assigning the sensor to an animal. After the sensors activation, we proceeded to confirm that all sensors were transmitting data and that the ear tag's signal was received by the routers. The selected group of cows were linked with the program's input wizard. The three-dimensional sensor in the ear tag device converts ear movements to electrical signals grouping them in one minute blocks of data. The collected data is sent every 15 minutes to the router or the coordinators; the routers transmits to the coordinator the data received from the sensors every 15 seconds, the coordinator hard wired to the computer sends it to the program installed in the farm's computer which interphase with the Agis Automatisering's cloud every 5 minutes uploading all the gathered movements information. Raw data is sent via the Internet to Agis and proprietary algorithms transcribe the data into appropriate graphs and behavior and temperature charts for evaluation and alerting. The alerts are updated every hour from the CowManager's server. The data transmitted to the receiver grouped in one minute intervals is subsequently blocked in periods of 60

minutes. The CowManager tag works at a frequency of 132.4 kHz and the accelerometer at 2 GHz

Teaching, research, and extension outreach uses and potential: The behavior monitoring system offers a wealth of opportunities in teaching, research, and extension venues. The system and its decision making have been incorporated into 7 classes, 5 undergraduate independent studies, 5 research projects, and used for many extension/ outreach opportunities.

Results and Discussion

Animal movements are transcribed into 5 events: highly active, normal active, non- active, ruminating, and eating. Increases in high activity coupled with associated behaviors are used to evaluate estrus and breeding decisions. Combinations of eating, rumination, and non-activity and changes are used to assess health events. Finally, temperature is a supplemental measurement to be used in health decisions. The following graphs and discussion will showcase these behaviors, and decisions associated with them.

Increased activity as an indicator of estrus and other behavior measurements for validation and decision making: Figure 2 shows an activity graph of cow 9421. The red line is the actual number of minutes/ hr. the animal is in high activity. The dark blue line is relative activity or the level of activity during that hour or time period compared to a 3-4 day prior baseline. This graph evaluates relative changes in high activity. Animals that exceed 2.8X normal high activity are alerted as a possible heat. Figure 2 represents this event where cow 9421 had an extended period of high activity and alerted as a possible heat. The light blue line is rumination time/ day. A characteristic of animals in estrus is decreased rumination. This is not shown in this graph, questioning whether this abnormal movement is estrus. Figure 3 shows a daily behavior graph of this animal during this period. During this period, activity was high but rumination was high and the animal was still having periods of non-activity (not typical of estrus). This animal had been moved to a different pen and barn and the activity reflects this change in environment rather than estrus. The additional behavior information and graphs help validate this decision. Figure 4 shows Cow 9491 and an increased activity alert on 4/2. This animal was on the heat stress project and her feed intake was decreased, indicating potential health issues. Animal evaluation showed no health issues. This graph showed the animal to be potentially in heat or estrus. Activity spike 21 days prior lend evidence to this even though this cow had been bred at 72 days and confirmed pregnant. Ultrasound this day showed cow 9491 open and in estrus. This graph also shows a decreased rumination pattern at this time which validates activity and estrus data. Figure 5 shows the daily activity data of cow 9491 at this time. High activity is elevated while rumination is greatly decreased. However, the only other behavior noted during this period shows eating (or green). Animals in estrus are not ruminating and usually not eating. This high level of" eating activity" is really constant head movements of animals in estrus that mimic feeding behavior and movement. The algorithm characterizes this movement as eating. While it may not be eating, the combined high activity with low rumination coupled to this continual head movement almost make100% accuracy in confirming heat and estrus.

Health events or aberrations: Health events or alerts are based on changes (increased non-activity, decreased rumination and/ or eating) and categorizes and alerts animals as suspicious, sick, or very sick based on degree of changes and combinations. Figure 6 shows a daily behavior graph of cow 3067J during a time where she showed a suspicious health alert on 3/21. An increase in non-activity, especially during hours post pm milking coupled with small decreases in eating and rumination alerted this cow. Fortunately, her continually monitoring showed quick improvement and return to normal by the following milking.

Ear temperature monitoring: Ear temperature is not core temperature and experiences daily and diurnal variation based on external temperatures. One benefit and aspect of temperature monitoring is that an individual animal is graphed simultaneously with the group ear temperature average (Figure 7). The graph shows the diurnal variation. In winter, ear temperature never reaches freezing and during summer hot weather, never goes above 95-98^{0}F. There is greater hourly variation in winter indicating thermal regulation, while less within hour variation in summer, since blood flow is consistent to ears for heat dissipation. There is a temperature alert but this feature is not validated in the system. The potential to identify fever is confounded as the ear reflects ear, and not core temperature. Also, blood flow is internalized and shunted from periphery in some health events. We have found this in a variety of health events (Figure 8) and see the evidence of ear hypothermia as a diagnostic tool validated potentially significant health events. So ear hypothermia may be the best diagnostic use for this system.

Teaching opportunities and uses: The behavior monitoring system and technologies has been presented and used in 4 animal science, 2 veterinary, and 1 agricultural engineering course. Also, some students have put the system on their computer and phone via an app and monitored the herd and system.

Independent studies: To date, 5 undergraduate independent studies have been conducted with the system (2 SWP and 3 An Sci 490). All studies consist of the 1st 2 months learning the system and evaluating, interpreting, and making decisions on all alerts, including a log and reference

of all these. An example of this log and work is shown in Figure 9. Following this, students choose a specific area to evaluate. This has included fresh cow management, transition cows, and calves.

Research opportunities: We have utilized and made tags available for other research projects and areas. To date there have been 5 projects: calving behavior associated with group or individual pen management (42 cows); heat stress induction model; LPS challenge study; calves; and evaluation of 1st lactation animals as they are initiated to Calan gate feeders.

Extension/ Outreach opportunities: Data and system use and evaluation has been presented at the ISU Dairy or in the field at many events and opportunities. Data can be accessed and shown via internet so make it relatively simple and portable to present anywhere. This has been used at ISUEO Dairy Days, and been major invited presentations at the I29 Winter Workshops and the 4 State Dairy Nutrition and Management Conference. Also, dairy producers, students, and others interested are given access to the system via internet and phone app and can learn the technology based on the ISU cows and herds. To date, 40+ people have or are doing this

Overall Summary and Conclusion

At Iowa State University, 36 animals were fitted with an ear tag based behavior and temperature monitor (Cow Manager, Agis Automatisering, Netherlands) to evaluate behavior and ear temperature change and learn the system. Tags were put on breeding age heifers, lactating cows, and transition cows. 34 other tags were acquired and put on transition cows. The system has served multiple purposes at the ISU Dairy. These include monitoring of animals and the herd from a commercial herd standpoint; teaching tool to introduce and embed undergraduate, graduate, and veterinary students in the technology (7 classes to date); a platform for 5 undergraduate independent studies to date; and utilized in 5 research projects to date including heat stress, calving behavior, LPS challenge model, calves, and evaluating animals as they adjust to Calan gate feeders. The system has also been a platform for extension presentations both at the ISU Dairy as well as many extension meetings and invited conferences and presentations. The behavior monitoring system has resulted in an excellent herd monitoring and decision system, as well as a teaching, research, and extension tool.

Figure 1. Cow Manager Behavioral Monitoring System (Agis Automatisering, Netherlands)).

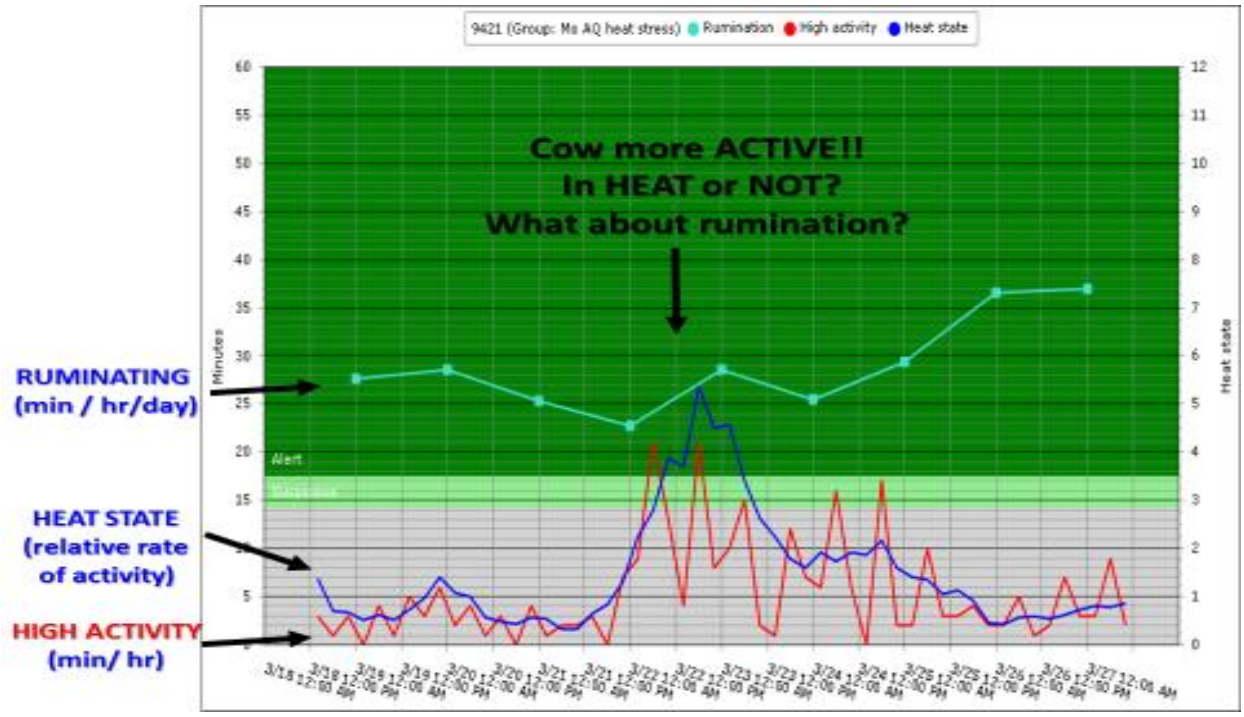
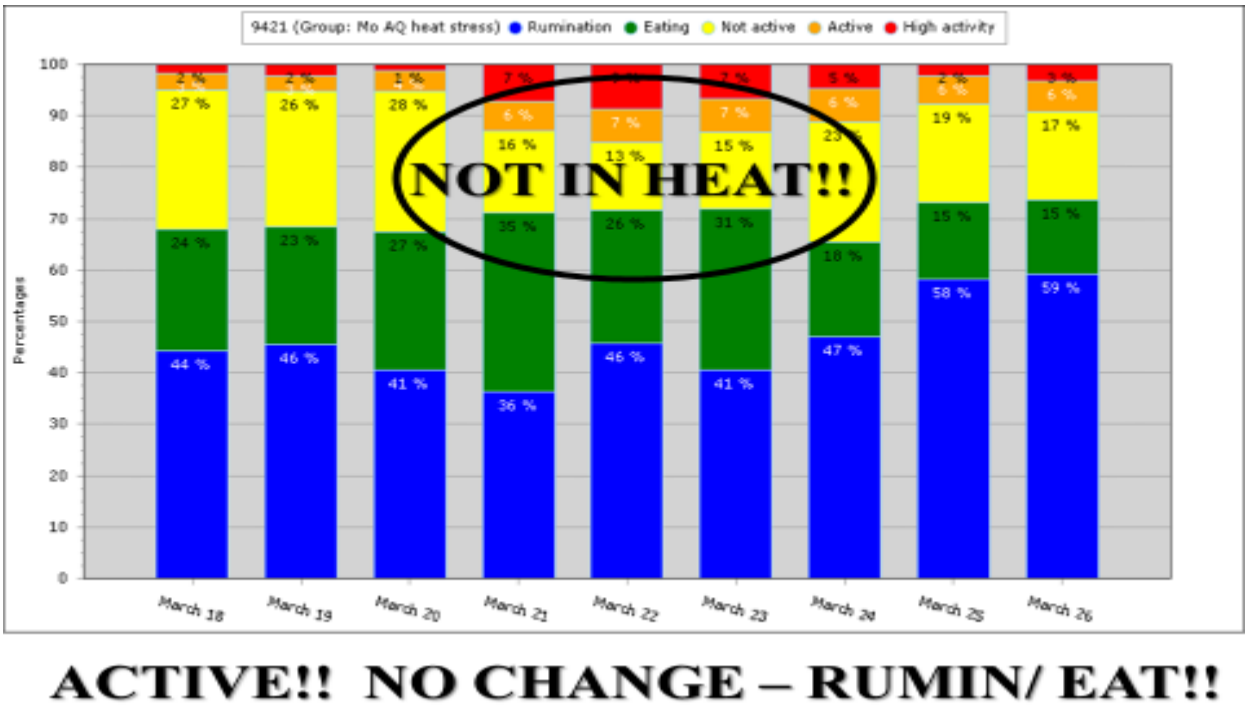


Figure 2. Activity monitoring of Cow 9421 and an alert event based on an increase in activity.



ACTIVE!! NO CHANGE – RUMIN/ EAT!!

Figure 3. Daily behavior data of Cow 9421 and an alert event based on an increase in activity.

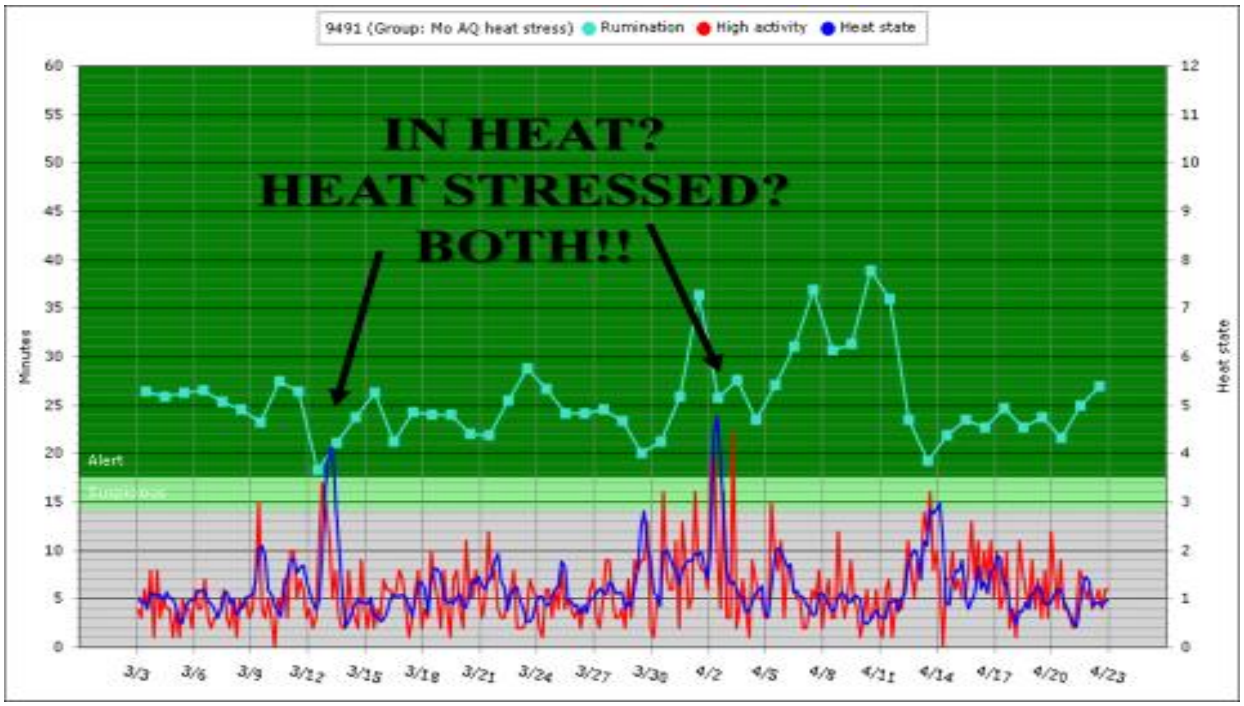


Figure 4. Activity monitoring of Cow 9491 and an alert event based on an increase in activity.

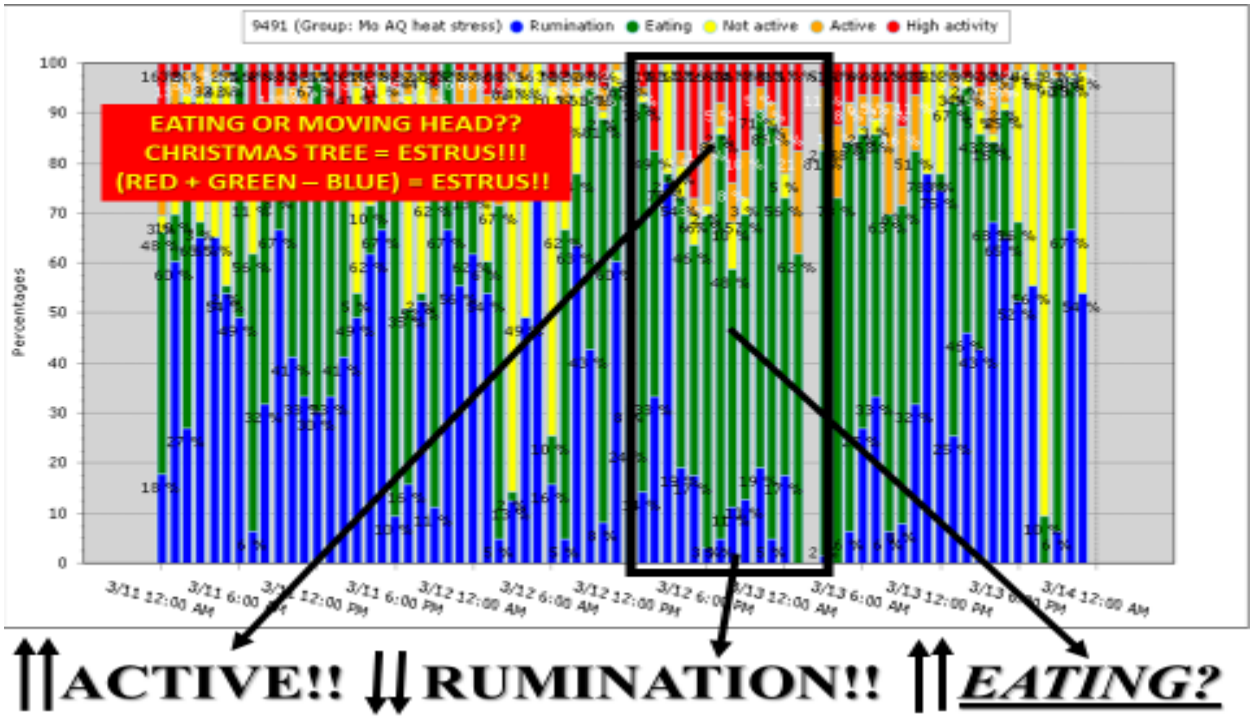


Figure 5. Daily behavior data of Cow 9491 and an alert event based on an increase in activity.

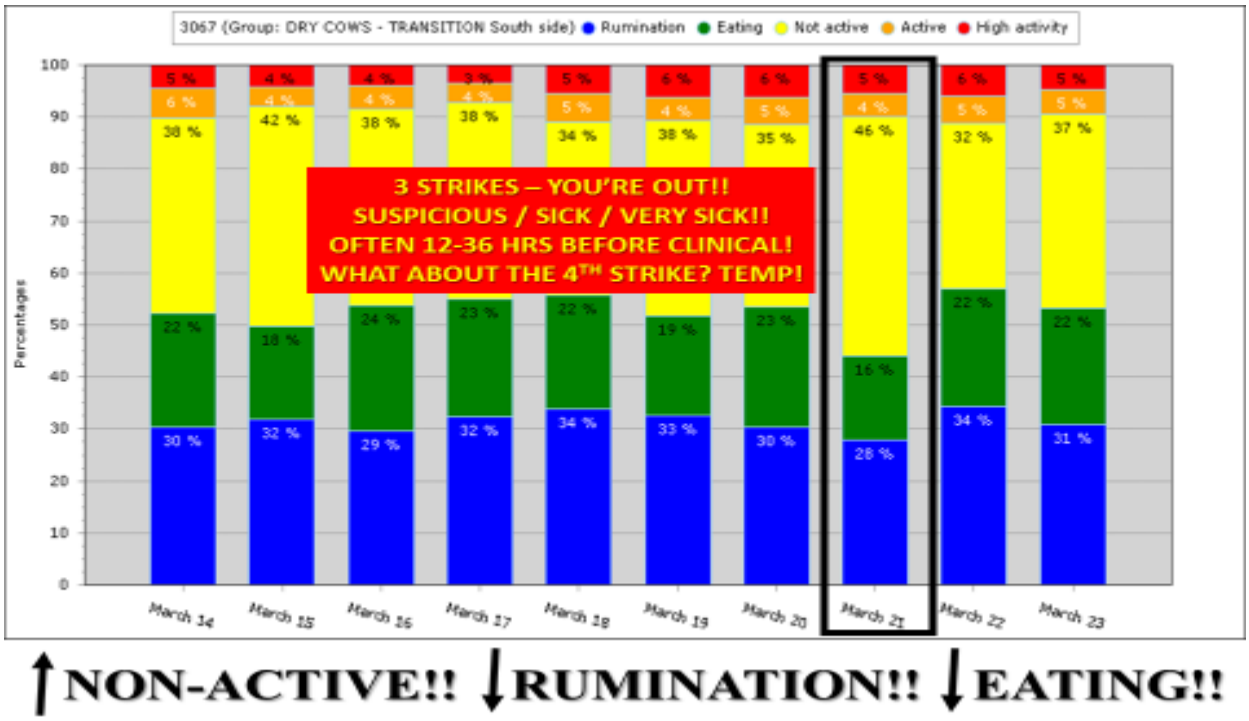


Figure 6. Daily behavior data of Cow 3067J and a health alert event based on increase non-activity and decreases in both eating and rumination.

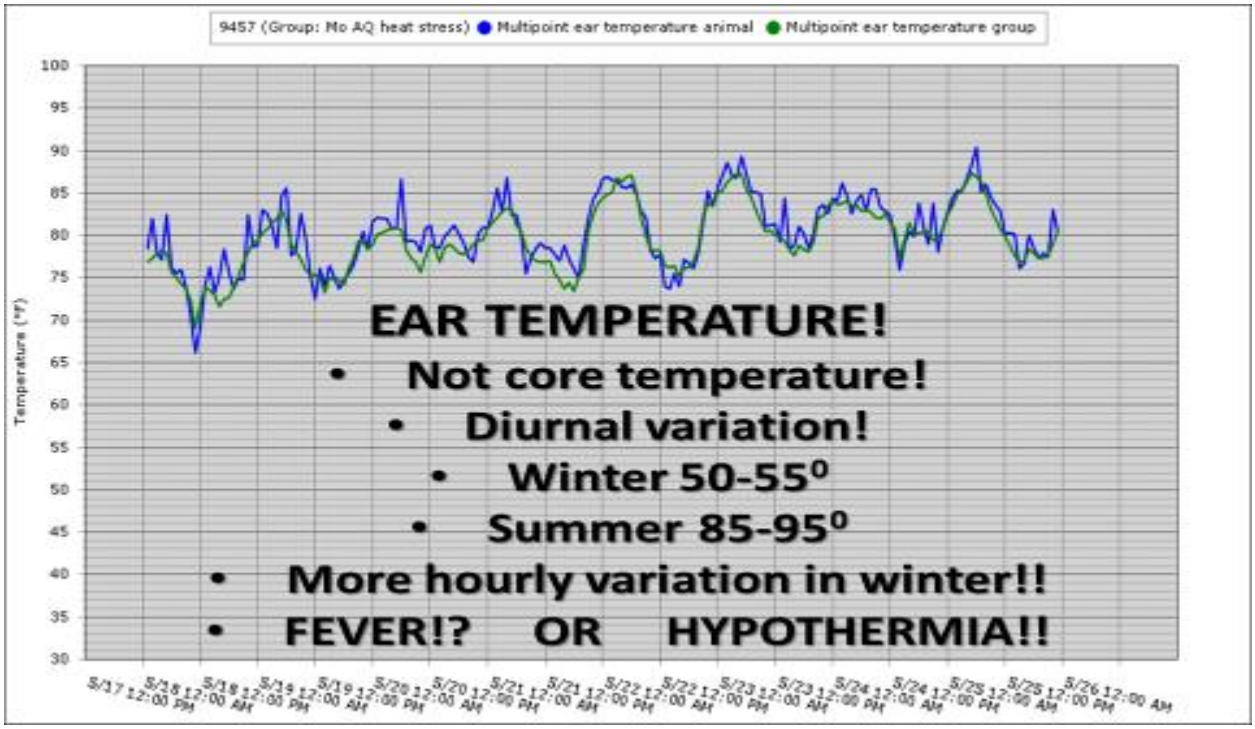


Figure 7. Ear temperature data of Cow 9457 and comments regarding characteristics of ear temperatures.

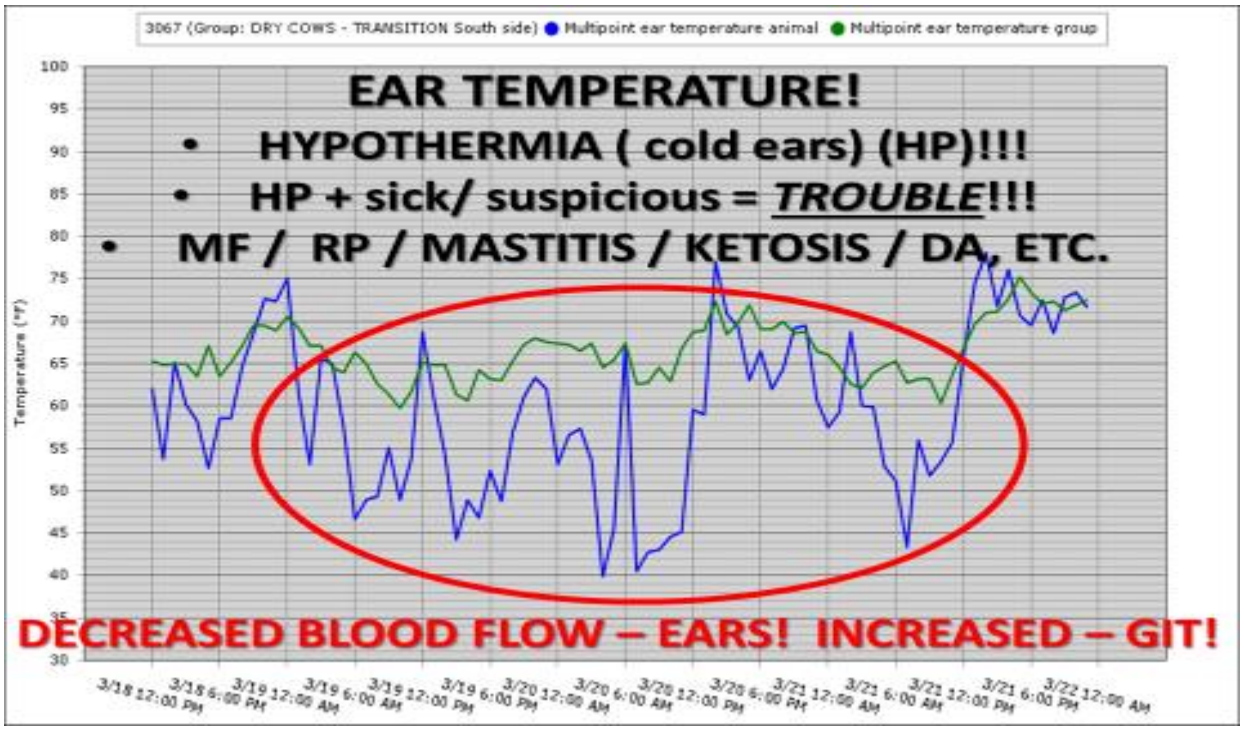


Figure 8. Ear temperature data of Cow 3067 during a sick cow health alert. Ear hypothermia is seen in many different health events and used as an additional health and problem indicator.

Alert Type: heat, dark green Descending 4.36/4.82
Cow #: 9718
Status: DIM 72, Fresh 8/7/16
Duration: 11 Time: 11:06 am Sep 29th
Activity Notes: High heat and VERY high activity (dark green)
"Day" Notes: Eating more, less "not active", less ruminating
Pictures:

Was she bred?
Yes, at 9/28/16

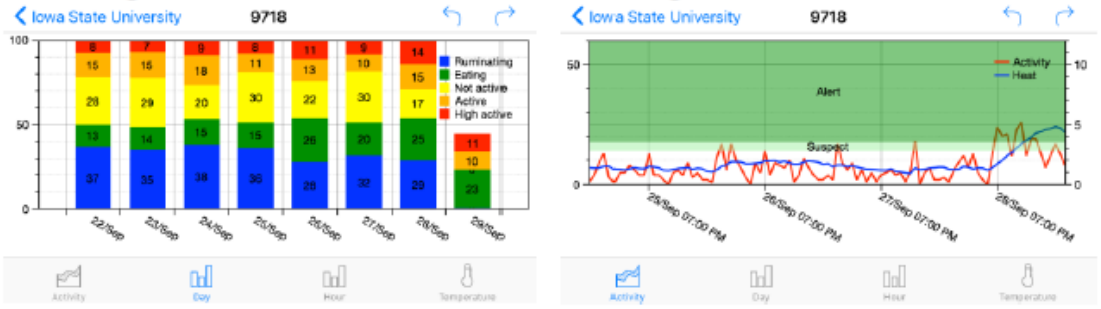


Figure 9. Behavioral and activity data and decisions journal of an undergraduate independent study project..