Abate Animal Heat Stress in Hot Weather

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Hot weather raises inevitable concerns about heat stress of animals. Heat stress affects animal production performance, well-being and health. The projected climate change and variability is expected to result in more extreme weather, which will likely worsen the heat stress problems in animal production. The total annual loss of the U.S. livestock and poultry industries due to heat stress could amount to $2.4 billion without abatement, but could be reduced to $1.7 billion with current ventilation and evaporative cooling abatement systems. It is very important for livestock producers to be able to understand, monitor, evaluate and effectively combat heat stress to reduce significant losses.

Heat Stress

Farm animals need to maintain relative stable body temperatures for good health and production performance. Animals gain heat through metabolism and the surrounding environment. Animals lose heat to the environment through surrounding air, water and objects through conductive, convective, radiative and evaporative heat transfer processes such as touching cool surfaces, exposure to high speed and/or cool air, breathing and perspiring. Animal heat stress occurs when heat gain is greater than heat loss, and when the animal cannot maintain stable body temperatures. Heat stress can result in low feed intake, poor production performance and possible mortality of animals.

How to Recognize and Estimate Heat Stress

Visible symptoms of heat stress are elevated respiration rates, abnormal body temperatures, feed avoidance, playing with water and crowding into shaded areas. When air temperatures exceed 77–78°F, most animals will suffer heat stress. Heat stress is increased when the relative humidity is greater than 50 percent. Table 1 summarizes the body temperatures and comfort zones (surrounding environmental air temperatures) of major farm animals.

<table>
<thead>
<tr>
<th>Farm Animals</th>
<th>Animal Body Temperatures</th>
<th>Comfort Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layers</td>
<td>105–109.4°F</td>
<td>55–70°F</td>
</tr>
<tr>
<td>Pigs</td>
<td>101.6–103.6°F</td>
<td>50–70°F</td>
</tr>
<tr>
<td>Cows</td>
<td>98–102.8°F</td>
<td>40–60°F</td>
</tr>
</tbody>
</table>

How to Monitor and Evaluate Heat Stress

Air temperature and relative humidity can be measured using portable air temperature and relative humidity sensors such as the HOBO T/RH sensor (Figure 1), hand-held indoor air quality meters such as the TSI IAQ-CALC™ IAQ-8762 (Figure 2a) or the TSI air velocity meter (Figure 2b), or any other air temperature and relative humidity sensors.

Figure 1. HOBO T/RH portable air temperature and relative humidity sensor (onsetcomp.com/products/data-logging/u23-001).
Temperature humidity index (THI) is a calculated index to combine effect of air temperature and relative humidity on animal comfort for evaluation of animal heat stress. It can be calculated in one of the following three ways (Hahn, et al., 2009), where the air temperature unit is °C and relative humidity unit is %:

\[ \text{THI} = 0.8 \times \text{dry bulb temp} + \text{relative humidity} \times (\text{dry bulb temp} - 14.4) + 46.4 \]

\[ \text{THI} = 0.72 \times (\text{dry bulb temp} + \text{wet bulb temp}) + 40.6 \]

\[ \text{THI} = \text{dry bulb temp} + 0.36 \times \text{dew point temp} + 41.2 \]

The THI threshold is the THI level at which heat stress begins. Table 2 outlines the THI threshold for different classes of animals.

<table>
<thead>
<tr>
<th>Animal class</th>
<th>THI threshold</th>
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<tbody>
<tr>
<td>Dairy cow</td>
<td>70</td>
</tr>
<tr>
<td>Dairy heifers (0 to 1)</td>
<td>77</td>
</tr>
<tr>
<td>Dairy heifers (1 to 2)</td>
<td>72</td>
</tr>
<tr>
<td>Beef cows</td>
<td>75</td>
</tr>
<tr>
<td>Finishing beef</td>
<td>72</td>
</tr>
<tr>
<td>Sows</td>
<td>74</td>
</tr>
<tr>
<td>Growing-finishing hogs</td>
<td>72</td>
</tr>
<tr>
<td>Poultry broiler chickens</td>
<td>78</td>
</tr>
<tr>
<td>Poultry layers</td>
<td>70</td>
</tr>
<tr>
<td>Poultry turkeys</td>
<td>78</td>
</tr>
</tbody>
</table>

- If the THI is less than the THI threshold of each type of animals, normally animals have no heat stress and are at their Normal state.

- If the THI is 1–4 degrees higher than THI threshold, mild heat stress is occurring and the animals are at an Alert state.

- If the THI is 5–9 degrees higher than THI threshold, animals are in intense heat stress, performance will be affected and the animals will be at a Danger state.

- If the THI is higher than the THI threshold by 10 degrees, the animals are at an Emergency state. This is very dangerous, and emergency measures need to be taken to reduce heat stress.

How to Assess Potential Economic Losses Due to Heat Stress

St-Pierre, et al. (2003), developed a series of statistic models to predict reductions in feed intake, body weight gain and changes of monthly mortality rate for poultry, swine and dairy operations. A heat stress load index (THI load) is used in the models. It is defined as time summation of THI in excess of THI threshold. For example, reduction in feed intake (kg per animal per day) for broiler bird was modeled as 0.22 × THI load / 168.

See more models of production and health parameters of different animal species in "Economic Losses from Heat Stress by U.S. Livestock Industries" (St-Pierre, et al., 2003). These economic loss models may be used to quantify the total economic losses due to heat stress for the whole production industry. They need to be further developed or calibrated to support operational decision-making at farm level.

In the United States, heat stress is causing significant economic losses to the animal industries. The annual losses are estimated as $1.7 to $2.4 billion with and without heat stress abatement measures. Among the losses, $897 to $1500 million are for the dairy industry, $370 million for the beef industry, $299 to $316 million for the swine industry and $128 million to $165 million for the poultry industry. Proper heat abatement can reduce the heat losses from 54 percent to 13 percent in different states of the U.S., and 28 percent for a national average (St-Pierre, et al., 2003). Clearly, there are economic interests and needs for applications of more energy and capital efficient heat abatement systems, especially in the climate change and severe variability environment.

How to Abate Heat Stress

To abate heat stress, reducing heat gain and helping to increase heat loss are fundamental strategies. Genetic modification and an energy-intensive diet can be used to reduce animal internal heat production. Increasing water intake can help animals lose internal heat.
This fact sheet focuses on engineering management approaches that are effective to reduce heat gain by shade and increase heat loss by ventilation, circulation fans, evaporative cooling and cooling management.

Shade and Cool Surfaces

Animals gain heat from the surrounding environment through thermal radiation, heat conduction and convective heat transfer. Direct sunlight together with heated surfaces create a significant amount of heat load to animals. A shade blocks the solar radiation heat that falls on the animals. According to a fact sheet by the Organic Agriculture Centre of Canada, it is especially critical for high-producing, large dairy animals. Shade cloth or other materials that do not block airflow can be used to block sunshine. Cool surfaces on which to lie can significantly reduce the heat load of animals as well.

Ventilation Management

Ventilation of animal buildings cools farm animals in mild and hot seasons by introducing cool and dry outdoor air into the housing areas (MWPS 32, MWPS 33 and MWPS 34). In summer, the maximum ventilation rate is needed to remove excessive heat and moisture from animal buildings. Producers should make sure enough ventilation is maintained by checking proper operation of the ventilation equipment, fan operation status, estimating the total ventilation rate against ventilation requirement, adjusting air inlets to maintain sufficient air intake and air speed and closing doors and windows to prevent air short circuiting. However, the ventilation process can only reduce indoor air temperature to three degrees above the outdoor air temperature. When outdoor temperatures are close to the indoor animal body temperatures, ventilation may increase animal heat stress.

Cooling or Circulation Fans

Air velocity increases convective heat loss of animals. In high-temperature environments, high-speed air movement is needed to increase heat loss of animals (Shearer, et al.). To effectively cool a cow or a pig, an air speed of at least 300 to 500 feet per minute (3.5 to 5.5 miles per hour) over much of the animal's body is needed. Circulation or cooling fans and tunnel ventilation models are typically used to increase indoor airflow speed. Producers should pay attention to the installation direction of the cooling fans to make sure they blow toward animals. Cooling fans can effectively increase air speed in areas ten times the fan diameter. A portable anemometer can be used to detect low air speed areas (Figure 2b).

Cooling Systems

Evaporation of water from wetted skin using sprinkler or mist systems is one of the most effective methods to remove heat from the body of an animal (Liang, et al., 2012). Wet-pad evaporative cooling and tunnel ventilation systems are also used in some swine and poultry buildings to supply cool air to the animals (Strobel, et al., 1999). The effectiveness of evaporative cooling relies on air relative humidity, air temperature and air speed passing the wetted surface. In hot and humid weather, the evaporative cooling method is not effective. Air conditioning systems are reported to be used in some dairy facilities in Florida (Brouk, et al., 2005). Considering the trend of global warming climate change, the economic feasibility and application of cooling systems to animal production facilities may change.

To learn more about cooling and ventilation systems of animal facilities, get the following books at www-mwps.sws.iastate.edu/catalog/ventilation-livestock-housing:

- MWPS 32, Mechanical Ventilation Handbook
- MWPS 33, Natural Ventilation Handbook
- MWPS 34, Heating, Cooling and Tempering Air Handbook

Summary

Heat stress affects animal production performance, well-being and health, and it results in significant economic losses in the animal industries. It is very important for livestock producers to be able to monitor, evaluate and effectively combat heat stress to reduce the significant losses. Experienced producers can detect heat stress through observation of visible symptoms of heat stress. However, simple sensor measurement can objectively show the degree of heat stress. A THI can be used to assess heat stress. Different animals have different degrees of heat stress tolerance, which are quantified by their THI thresholds. Four stages of heat stress are defined as Normal, Alert, Danger and Emergency. Economic loss can be estimated using statistical models. Various heat stress abatement management and technologies are available. It is important for producers to reconsider the economic feasibility and application of cooling systems on farms.

Acknowledgments

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References


