Environmental Quality in Dairy Housing

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Dairy housing provides shelter and creates a modified environment for calves, heifers, and cows. Many factors including weather, building design, and management affect the environment created. The environment that the dairy animals experience in turn affects their well-being. Indicators of well-being include: reproduction and production performance, pathological and immunological traits, physiological and biochemical characteristics, and behavioral patterns *(Consortium for Developing a Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching, 1988).* Producers trying to improve the performance of their dairy need to consider and evaluate the quality of the environment created by their housing, the well-being of their animals, and the profitability of their business. However, many dairy managers have very little quantitative information on the dairy housing environment that they create for their animals.

The purpose of this presentation is to propose that dairy producers begin monitoring select environmental characteristics in their dairy housing facilities to provide quantitative information about the performance of their facilities and its impact on the well-being of their dairy animals. Good management requires accurate performance data to compare against performance standards to identify problem areas or areas for improvement. For good dairy producers to continue too improve upon their existing performance they need to establish environmental performance standards, begin monitoring, evaluate performance, and implement appropriate management changes when performance is not acceptable.

Dairy housing is interconnected with other aspects of a dairy operation. Housing facilities affects animal flow and grouping (ex. calf hutches, small group pens or super calf hutches, and larger group pens). Housing also impacts feed handling, manure management, animal movement and handling, and labor efficiency. Good dairy housing layout and design must incorporate these criteria to provide structurally sound and safe facilities for both the dairy animals and people working with them. Many dairy farmsteads include housing stock that ranges from very poor to excellent. The environmental performance criteria may vary with the quality of the housing. This however is a management decision and should be made deliberately rather than by default.

Dairy housing must provide an acceptable environment that meets the needs of the calves, heifers, and cows housed. The environment in livestock facilities is often incompletely defined and difficult to characterize definitively (Hahn *et al.*, 1983). Hahn *et al.* (1983) defined environment in a broad sense to include all nongenetic factors influencing an animal. The environment includes all conditions except those imposed by heredity and includes external factors (e.g., temperature, light, moisture, social factors) as well as internal factors (e.g., nutrition, disease organisms, parasites) (Cast, 1981). With such an inclusive definition for the term environment it is practically impossible to completely and quantitatively measure an animal's environment. For this discussion on dairy housing, the environment will be limited to the characteristics listed in Table 1. Monitoring and evaluating environmental conditions based on these characteristics is expected to help producers to continue to improve the existing environment created in their dairy facilities.

Table 1.

Selected environmental characteristics
Temperature (dry-bulb air and surface)
Moisture (air and surfaces)
Air velocity (drafts)
Light (level, quality, photoperiod length)
Airborne contaminants (dust, gases and aerosols)

The characteristics in Table 1 do not completely define an environment. For example, dry-bulb air temperature, the temperature commonly measured with either liquid-in-glass or digital thermometers, is commonly used to represent the entire thermal environment. However, air temperature does not describe the radiant environment, heat gain or loss by radiant heat exchange to surround hot and cold surfaces. Also, air temperature alone does not describe the thermal effect of both evaporative cooling from animals with wet coats and

Paper presented at the Minnesota Dairy Health Conference, May 21-22, 1997.

convective heat exchange from animals in drafts. In some cases these other environmental characteristics can have a significant effect on an animals effort to maintain homeothermy.

Desired Environmental Conditions

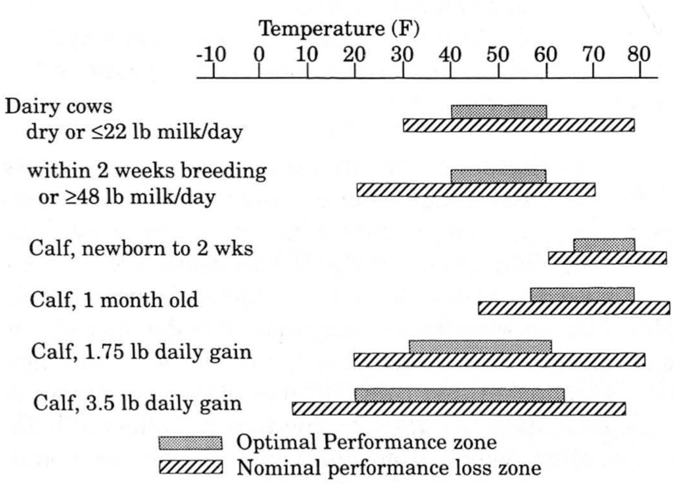
The desired environmental conditions are a management decision based on animal well-being, economics, and management preferences. Desired conditions usually change with season and animal age. As environmental conditions approach the boundaries of the desired conditions, animal care givers need to decide whether to implement corrective actions (i.e., change ventilation rates, open or close curtains, add bedding, adjust thermostats) to maintain desired environmental conditions. In many instances short term excursions beyond the desired environmental limits are not a cause for significant concern.

The desired environmental conditions described here are the result of a brief literature review and limited personal experience. Other resources should be considered before adopting these environmental conditions.

Temperature

Figure 1 from Hahn (1983) gives temperature ranges for optimum performance and nominal performance losses. Hahn (1983) states that "the values represent a large majority of each species population, variations in health and general physical conditions, acclimation to seasonal conditions, adequacy of feed and water, freedom from parasites and other pests, and thermal factors other than temperature can alter the response of individual animals." Temperatures shift upward when animals have wetted skin or exposed to drafts. Temperatures shift downward when animals are exposed to high humidities or solar radiation.

Figure 1. Optimal and nominal performance zones for dairy animals (Hahn, 1983).



Moisture

Recommended relative humidity levels generally range from 50 to 70% in animal facilities. Higher relative humidities are associated with increased respiratory health problems and condensation on cold building surfaces. Two cold weather studies suggest that milk yields decline when lactating cows are housed in facilities that have relative humidities higher than 70% (MacDonald *et al.,* 1958; Williams and Bell, 1964). High dew-point temperatures (i.e., greater than 60° F) during hot weather can contribute to heat stress by reducing evaporative cooling. Lower relative humidities are associated with dusty conditions.

Wet surfaces (i.e., wet manure packs, freestalls, and muddy exercise lots) contribute to heat loss. In cold environments the additional heat loss may contribute to thermal stress and reduce animal well-being (Christopherson, 1983).

Air velocity (drafts)

Desired air velocity past dairy animals is very dependent on air temperature. In mild to warm weather air velocity has little effect on animal well-being. At 65° F, air velocity changes from 40 to 750 feet per minute (fpm) had little effect on sensible heat loss (Thompson, 1957). In hot weather, air velocity and water sprinkling are used to increase evaporative cooling (Chastain and Turner, 1994). In cold weather, drafts increased heat loss that can negatively impact animal well-being. When air temperatures are between 16 and 25°F, air velocity changes from 40 to 750 fpm produced 25 to 40% increases in sensible heat loss (Scott *et al.,* 1983).

Draft free is not a defined term. Draft free environments, air velocities less than 50 fpm, are commonly recommended for neonatal animals of all species. In many research reports the minimum air velocity reported is often due to the limits of the instruments used to measure air velocity.

Lighting

Dairy housing lighting is important for creating a high quality working environment to improve worker efficiency, safety and comfort and for providing the lighting needed for animal well-being. There are three lighting characteristics: light level, quality, and photo period length. Table 2 lists recommended light levels (ASAE, 1996). Light quality involves uniformity, glare, and color rendition index. High uniformity and low glare is important for offices, animal treatment, and milking areas. Color rendition describes the whiteness of the light. In areas with correct color perception it is important to use lights with color rendition index values of 80 to 100. Research trials indicate that lactating cows exposed to 16 to 18 hours of light (<10 fc) per day had milk production increases ranging from 5 to 16% compared to cows exposed to 13.5 hours or less of light per day (Peters, 1994).

Table 2. Recommended light levels for common indoor work areas in dairy housing (ASAE, 1996).

Work Area	Minimum Illumination (fc)
Milking area (stall barn or parlor)	
General	20
Cows udder	50
Milk room	
General	20
Washing area	100
Bulk Tank Interior	100
Loading Platform	20
Feeding Areas (manger or bunk)	20
Feed Handling	
Storage	5
Mixing and inspection	20
Machine Storage	10
General livestock housing, maternity, and holding area	10
Office	100
Restrooms	20

Air contaminants

Research on air contaminants in dairy housing is limited compared to other livestock species. Nordstrom and McQuitty (1975) reported that threshold limits for calves appear to be 20 ppm for hydrogen sulfide and 50 ppm for ammonia. Hydrogen sulfide alone at 20 ppm and ammonia alone at 65 ppm resulted in reduced appetites and together had an increased effect on appetite reduction. Anderson *et al.* (1978) discussed the importance of air contaminants and pathogenic aerosols and their control in dairy housing, but no quantitative limits were not suggested.

Monitoring Tools

There are a large number of commercially available tools for monitoring the environmental characteristics listed in Table 1. Several factors need to be considered when selecting monitoring tools. These include: accuracy, measurement scale, cost, ease of use, durability, automation, and number of measurements to be taken (locations and times). In all cases the devices need to be located where they will not be physically damaged by dairy animals or machinery. Some units also need protection from dust and corrosive gases found in animal facilities.

Temperature

There are numerous devices available for measuring dry-bulb air temperatures. Liquid in glass thermometers are very common. They have good accuracy, ±0.3F, and are quite durable if protected from physical damage. Electronic thermometers are also very common and quite good. Some electronic thermometers can be installed with several sensors located at different places throughout the dairy facilities and a single readout with a switch. This setup facilitates taking and recording several readings throughout the facilities. Large dial thermometers usually use metallic strips to sense temperature changes. They usually are less accurate and tend to corrode over time in animal facilities. They also tend to be located well above animal level to prevent damage by the animals. Maximum/minimum liquid in glass thermometers are recommended for monitoring temperature changes over a period of time. They are useful for measuring the temperature fluctuation in a facility. Hand-held temperature sensors can be used to take current readings and make spot checks but they do not provide information during other time periods.

Moisture

There are fewer options for measuring moisture in the air (i.e., relative humidity or dew-point temperature) in animal facilities. The vast majority are manually operated. Psychrometers, either sling or motorized, have two thermometers. One thermometer measures dry-bulb temperature while the other, cloth covered and wetted, measures wet-bulb temperature. These two temperatures, dry-bulb and wet-bulb, are used to find the relative humidity and dew-point temperature. Electronic hand-held and remote humidity sensors are available. Durability, accuracy, and cost are factors with electronic humidity sensors. Hygrothermographs can be used to measure and record relative humidity levels. Their accuracy is usually no better than ±5% relative humidity and they need frequent recalibration.

Air velocity

There are a number of devices available for quantitatively measuring air velocity. Hand held hot wire anemometers are the most common devices used to directly measure air velocity. Many units also have a temperature sensor in the probe. Cost and accuracy are important. It is desirable to be able to measure velocities from 50 to 2,000 fpm. In mechanically (i.e., fan) ventilated buildings it is desirable to have a manometer to measure the static pressure difference between inside and outside. Properly designed ventilating systems operate between about 0.04 and 0.1 inches of water gage pressure. Manometers are liquid filled and cannot be used in buildings that have temperatures that drop below freezing. In dairy facilities that have inside temperatures that drop below freezing, magnehelic gages should be used to measure static pressure.

Smoke is sometimes used to locate dead spots or drafty locations (MWPS-32, 1990). Smoke is difficult to interpret in slowly mixing air flows. Smoke generated by insect foggers, cigars, or other burning sources may not accurately show the airflow because warm smoke tends to rise rather than follow the air flow. Chemical smoke generators do not have this problem but are more expensive. A bottle of talcum powder when shaken and squeezed can release a cloud of dust for checking micro-currents and poses no fire hazard (MWPS-32, 1990).

Lighting

Light levels are measured with a light meter. In animal agriculture, hand held light meters with multiple scales are most common. These are used primarily to make spot measurements. Accuracy will depend on the scale being used. It is desirable to have an accuracy of at least ±0.5 foot-candles (fc) at a scale that goes up to 50 fc.

Light uniformity is indicated by measuring light levels at the same elevation but different locations in a space. The uniformity ratio is defined as the maximum light level measured divided by the minimum (ASAE, 1996). Uniformity ratios are recommended to range from 1.5 for visually difficult tasks to 5 for visually less difficult tasks.

Air Contaminants

Air contaminants can be categorized as gases, dust, and airborne microorganisms. Gas concentrations are usually the first air contaminants monitored. Dust and airborne microorganism monitoring requires special equipment and facilities which are not commonly available. The following comments are based on air quality research experience in swine and poultry facilities.

Gases

Gas concentrations in animal facilities are commonly monitored using colorimetric detector tubes. These tubes are designed to measure the concentration of specific gases. Tubes are available to measure a wide range of specific gases over a range of concentrations. Two types of one-use tubes are commonly used. Indicator tubes give an essentially instantaneous reading using a measured amount of sample air. Indicator tubes give current concentrations and can be used to try to find peak concentrations. Diffusion tubes give a time averaged concentration by sampling over a several hour period. These tubes are left in a facility for several hours before reading.

There are also infrared and electronic sensors for measuring gas concentrations. These are not used widely because of their cost and reliability in an agricultural setting.

Dust

Dust can be measured gravimetrically using filters and air sampling pumps or electronically using optical techniques. The electronic particle counters can give an instantaneous reading. The units are expensive, require yearly factory recalibration, and are not used widely to monitor dust levels in agricultural facilities.

Filters with sampling pumps can be used to monitor either total, respirable or inhalable dust concentrations. The sampled air is drawn through a filter by a vacuum pump. For total dust, all of the dust in the air sample is drawn through a cyclone that removes the larger dust particles (cut diameter of 5μm). Inhalable dust samplers simulate the dust collection of the human nose and mouth, able to trap particles up to 100 μm in diameter. When using filters air samples are collected over a period of several hours.

Airborne Microorganisms

Airborne microorganisms are difficult to measure. Specialized air sampling equipment is used to collect the microorganisms. Laboratory facilities for diluting, growing and counting microorganisms is required. This procedure is not typically used in dairy housing evaluations at this time.

Environmental Evaluation and Management

Environmental evaluation and management involves selecting a limited number of environmental characteristics, setting performance standards, monitoring them in dairy housing, and using the information to improve environmental management, animal well-being, and profitability. It uses benchmarking principles, where objective measurements are used to evaluate performance against performance standards.

There are numerous situations where environmental monitoring and evaluation is expected to provide valuable information for making management decisions. Sometimes when a dairy operation experiences animal health problems, veterinarians will express concerns about the environmental conditions. Some dairy producers that move into new curtain sided naturally ventilated freestall barns express concerns about the cold temperatures in the new facilities in very cold weather. In both these situations, little quantitative and recorded information exists to review and evaluate. These are situations where a monitoring program would be helpful.

Good dairy producers can also use environmental monitoring information to evaluate their housing and its management. Producers that try to keep a curtain sided barn with an uninsulated roof warm enough to keep manure from freezing in very cold weather usually end up with condensation, frost, and high humidities. In hot weather, temperature and humidity data measured in the barn would help determine how much heat stress lactating cows experience. Monitoring helps determine how often and how long these conditions exist, whether it is acceptable or unacceptable, and whether changes are warranted. With the environmental information, good producers can make management decisions to improve their existing performance, animal well-being, and profitability.

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Abstract

Comparison of Histology With Maternal and Fetal Serology for the Diagnosis of Abortion Due to Bovine Neosporosis

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Veterinary Record (1997) 141, 487-489

An indirect fluorescent antibody test was applied to sera from normally calving and aborting cows and to samples of pleural fluid from their aborted calves, and the antibody titres were compared with histology and immunocytochemistry for the diagnosis of *Neospora*-associated abortion. Two groups of aborting cows and a third group of cows which had calved normally were used; group A consisted of 36 cows which aborted calves showing characteristic non-suppurative inflammatory lesions in which *Neospora* was demonstrated by immunocytochemistry, group B consisted of 100 cows which aborted calves without histological evidence of neosporosis, and group C consisted of 128 normally calved cows which were sampled within one month of calving. Serology on the maternal sera and fetal fluids was highly specific and sensitive for *Neospora* infection although 5 per cent of the cows which aborted *Neospora*-negative calves and 4.7 per cent of the normally calved cows were also seropositive. Anti-*Neospora* antibodies were also detected in 7 per cent of the samples of fetal fluid from *Neospora*-negative abortions.