Effects of the Environment on Neonatal Dairy Calf Health

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Disease is not a chemical equation where host and agent are brought together, incubated at 37°C, and clinical signs are thereby produced. On the contrary, infectious agents are part of the environment of all animals; this does not mean that infection is inevitable nor does the fact of infection mean that disease is inevitable. It is difficult to think of a bovine disease agent for which infection usually leads to clinically recognizable disease.

Most neonatal calf losses have been associated with diarrheal and/or respiratory disease. In a recent survey of 19 NE Ohio herds in which a history was obtained for every calf death, 78% of deaths were immediately preceded by signs of diarrhea and/or respiratory disease.[1] Both of these conditions are known as disease complexes since a variety of infectious agents can be associated with them. It has become clear in recent years that at least some of the agents of diarrheal and respiratory disease are ubiquitous. Certainly there are agents sufficient to produce serious diarrheal and respiratory diseases on every farm. Low morbidity/mortality farms were identified in the NE Ohio survey on which rotavirus, cryptosporidia, Salmonella, and enterotoxigenic *E. coli* were all resident. No sampling was performed, in this study, for respiratory agents, but there can be little doubt that *Pasteurella* and respiratory *Mycoplasmas* as well as a variety of respiratory viruses exist on every farm. Serologic studies suggest that *Haemophilus* is also very widespread and that infections with it are most commonly subclinical.[2]

Those who hold the "disease-because-agent" hypothesis as sacrosanct may find these points disturbing. But in the words of Francis Bacon, those who seek knowledge should "lay their notions by and begin to familiarize themselves with the facts." The data seem to support a conclusion that infection with a variety of diarrheal and respiratory agents is an inevitable part of being a calf and that infection need not be totally prevented in order to minimize disease losses. It appears, from a functional standpoint, that in the triad of disease causality (agent, host, environment) host and environmental factors predominate. This article will examine the effects of several environmental factors on dairy calf mortality and morbidity.

Exposure Dose

Perhaps the most important role of the environment is its effect on the exposure dose. Calves are not like blood agar plates or cell cultures in which a single, viable microorganism will produce "infection." For every agent, a certain threshold exposure dose is required to achieve infection. A higher dose is required to produce clinical signs (clinical threshold dose). Increased levels of exposure beyond the clinical threshold dose result in an increasing severity of disease. Environments favoring relatively low exposure doses result in no infection, subclinical infection, or only mild disease.

Passive immune levels have an important influence on the effect of a given exposure dose. The lower a calf's level of passive immunity against a specific agent, the lower is the exposure dose required to produce disease. In the same manner, a dose beyond the clinical threshold will produce more severe disease in a calf with a low level of passive immunity as compared to one with a high level of passive immunity.

It is possible to rear calves which receive little or no passive immunity, but the exposure dose of disease agents in the environment must be kept low. In the NE Ohio survey, there was a substantial number (21.0% of calves sampled) of hypogammaglobulinemic calves (total immunoglobulin less than 5.0 mg/ml) even in low mortality rate herds, but these immunodeprived calves experienced only a 5.1% mortality risk. In contrast, hypogammaglobulinemic calves in high calf mortality herds (34.7% of calves) suffered a 38.5% mortality risk.

Thus, it can be seen that calf disease involves a complex interaction of agent, host, and environmental factors. It is impossible to separate their effects. Nevertheless, low calf mortality rate herds were identified in the NE Ohio survey in which infection with several agents was commonplace and in which a large percentage of calves were hypogammaglobulinemic. This suggests a prominent role of environmental factors in the control of calf diseases—most notably those factors influencing the level of environmental contamination and thus the exposure dose. Table 1 gives an outline of factors which can influence the exposure dose.

Spatial density. Spatial density refers to how closely calves are housed together. It is difficult to limit the exposure dose in high-density, enclosed housing. Partitions placed between calves do not eliminate the heavy exposure dose since both diarrheal and respiratory agents can be spread by aerosol.

In the NE Ohio survey, the diarrheal morbidity rate was higher in enclosed, artificially ventilated, heated barns than

TABLE 1. An outline of factors influencing the exposure dose of infectious agents.

I. Factors influencing the rate at which the environment is being contaminated.
   A. Spatial density
   B. Temporal density
   C. Density of non-immune, heavy shedders
II. Factors influencing the survival time of agents in the environment.
   A. Ventilation
      1. Air turnover
      2. Humidity
   B. Frequency of bedding changes
   C. Sunlight and disinfectants

in hutches or cold barns. Many dairy farmers using enclosed housing also complain of continual difficulties with respiratory disease among neonatal calves. Indeed, the trend toward the use of hutches and other forms of cold, naturally ventilated housing seems to have been spurred by the high diarrheal and respiratory morbidity rates experienced by calves in enclosed, high-density housing.

Temporal density. Temporal density relates to the period between peak shedding intervals of successive occupants of a hutch or individual calf pen. In the case of diarrheal agents, infection most commonly occurs during the first 3 weeks of life and shedding ensues for 4 to 7 days. With rotavirus and cryptosporidia (the 2 agents studied extensively in the NE Ohio survey), most shedding was found to occur between 8 and 16 days of age. The same pattern was seen in all herds sampled.

Agents have a half-life in the calfs immediate environment. This is due not only to inactivation but to continual removal of infectious agents via ventilation, bedding changes, and the flushing action of urine and any water used. Also, infectious agents remaining are diluted by the continuous addition of uninfected feces and bedding material. Thus, the longer the interval between the peak shedding intervals of successive occupants of a hutch or individual pen, the lower the exposure dose that will occur.

Herds which use hutches have an option which obviates the whole problem of temporal density; hutches can be moved between successive occupants. However, this was not the most common practice among herds in the NE Ohio survey; most never moved hutches or moved them only occasionally.

Herds using enclosed, high-density housing also represent a special case with respect to temporal density. Although increasing the time between successive occupants of a pen will likely decrease the level of environmental contamination, agent numbers tend to build up in any case in high-density housing. A break in the use of the facility during which the floor and pens are thoroughly disinfected can have a dramatic impact on the level of environmental contamination. Several examples of this were seen in the NE Ohio survey in which extremely high morbidity rates were replaced by low rates among the first 10 to 20 calves to reoccupy the facility after the break. Subclinical infections continued to occur among these first few calves, and increasing environmental contamination eventually returned the herds to their previously high morbidity levels.

The marked irregularities in the number of heifer calf births per month which occur in most herds add to the difficulties associated with both spatial and temporal density. The coefficient of variation (standard deviation ÷ mean) of monthly heifer calf births varied from 21.6% to 82.7% among herds in the NE Ohio survey. There was an inverse relationship between coefficient of variation and herd size. Where 15% to 25% of all the heifers born in an entire year arrive during a single month, a tremendous burden is placed on calf rearing facilities. Farms using hutches are often forced to double-up calves while others commonly use temporary, group housing. Calves may be weaned early and moved out to free pens for newborn calves (thus increasing the temporal density). Unless considerable surplus housing is available, a heavy rate of calving over a month or two interval will inevitably lead to increased environmental contamination and increased exposure doses.

Density of non-immune, heavy shedders. Calves with low levels of passive immunity are not only at increased risk themselves, but they also place their cohorts at increased risk. For at least one diarrheal agent, rotavirus, it has been shown that calves with low levels of passive rotaviral antibody will shed greater numbers of viral particles, thus increasing the exposure dose for other calves.[3] This is an excellent example of the concept of herd immunity where one individual's immune status influences the well being of others.

Ventilation. As shown in Table 1, several factors influence the survival time of infectious agents in the calfs immediate environment. For enclosed structures, the ventilation system plays a key role in this regard. It controls the humidity level which in turn influences the survival time of infectious agents. The air turnover rate also determines the rate at which agent laden aerosols are removed from the calf barn. If these aerosols are not removed they eventually settle on any exposed surfaces (e.g. the calves' haircoats, feed buckets, water buckets) or they are breathed in by the calves and deposited in their respiratory tracts. The spraying of contaminated pens and floors with a water hose only compounds the problems of ventilation, leading both to increased humidity and the formation of multitudes of aerosols.

Frequency of bedding changes. Changing the bedding or just adding a layer of fresh bedding over the pack will result in a dilution effect of agents present. This will benefit not only the calf currently in a pen or hutch but, as mentioned previously, its successor as well.

Sunlight and disinfectants. Where hutches are moved between successive occupants and the old bedding is dispersed, sunlight and the elements will inactivate most of the infectious agents over a several month period. Some agents are quite hardy (e.g. rotavirus) and will probably not be totally eliminated, but the exposure dose will be greatly reduced. There is no evidence, to the author's knowledge, that the use of disinfectants on contaminated soil offers an advantage.

For barns with concrete floors a variety of disinfectants are available. Some disinfectants are not effective against certain microorganisms; rotavirus, in particular, is resistant to many types of disinfectants. Phenol-derivatives are widely used on dairy farms for environmental disinfection and these are reportedly efficacious against rotavirus.

Direct Environmental Effects

In addition to enfluencing the exposure dose, the environment can have several direct effects on the well being of the neonatal calf. Several of these are discussed below.

Cold temperatures. Cold temperatures, in themselves, do not seem to be harmful to calves. Several farms in the 1982 NE Ohio survey reared calves in hutches with very low mortality rates in spite of the fact that January and February of 1982 were unusually cold. Where calves are well bedded, protected from wind and moisture, and provided with ample nutrition; it appears that they can withstand temperatures at least as low as -20°F with little or no increased mortality risk. Studies in South Dakota,[4] Ontario,[5] and Scotland[6] are in agreement with these observations.

The precise nutritional requirements of calves reared in cold housing during the winter months has not been delineated. However, a Scottish study[6] found that calves reared on 0.6 kg of milk replacer per day (day matter basis) experienced a lower mortality rate than calves reared on 0.3 kg per day (7.8% vs. 12.6% mortality, respectively). On a whole milk equivalent basis, these two feeding levels extrapolated to approximately 11.5% and 5.8% of the body weight daily. Increased intakes of grain among the calves on the lower level of milk replacer partially compensated for the energy deficit. Whether or not daily intakes of 8-10% of body weight on a whole milk equivalent basis which are commonly fed to calves represent an adequate amount during cold weather has not, to the author's knowledge, been demonstrated.

Since calves can be reared with excellent success in cold environments, it must be assumed that their haircoats have excellent insulating properties. Moisture and wind can greatly decrease the effectiveness of the insulating value, however. Moisture can come either from wet bedding or, in enclosed housing, from high humidity. Exposure to wind can result from failure to have tightly constructed hutches flush to the ground or from drafty, enclosed structures.

Thermal stress. Heat stress can have a deleterious effect on calves. High environmental temperatures can result in increased levels of corticosteroids which in turn can have a deleterious effect on a variety of host resistance mechanisms. Also, newborn calves exposed to high environmental temperatures have been shown to absorb reduced amounts of colostral immunoglobulin.[7]

Calves reared during the summer months in hutches without windows will frequently be found to have rectal temperatures above 103°F. Not only does this have the deleterious effects mentioned above, but it increases the water needs of calves as well. The importance of a clean, palatable water source is sometimes overlooked by management in high calf mortality herds.

Ventilation. In enclosed structures, the ventilation system can have a direct effect on calves' resistance in addition to the effects on exposure dose mentioned previously. Fumes which build up in poorly ventilated structures can be damaging to the clearance mechanisms of the respiratory system. This effectively reduces the exposure dose required to produce disease.

Conclusion

Diagnosis of excess dairy calf morbidity/mortality requires a detailed analysis of management practices including those related to the environment. Simply looking for infectious agents will accomplish little since the same agents can be found on low as well as high morbidity/mortality rate farms.

References

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