The American Heritage Dictionary defines environment as "the combination of external physical conditions that affect and influence the growth, development, and survival of an organism or group of organisms". Relative to bovine mastitis, the environment influences both of the principal groups of participants: bacteria and cows.

Specifically, environmental conditions will affect the rate and magnitude of bacterial growth in the cows' surroundings. The other primary factor determining the incidence of environmental mastitis is the mammary gland host defenses. The same environmental factors that increase the growth of common mastitis pathogens often have a negative effect on mammary defenses.

The Bacteria’s View

The primary environmental mastitis pathogens include Escherichia coli, Klebsiella pneumonia, and Streptococcus uberis. These bacterial species require organic material to utilize as food. Bedding materials commonly used for lactating and nonlactating cows provide an excellent environment for propagation of mastitis pathogens.

Populations of the bacteria in bedding are related to the number of bacteria on teat ends and rates of clinical mastitis. Therefore, reducing the number of bacteria in bedding generally results in a decrease in environmental mastitis.

Coliforms and streptococci cannot live on teat skin for long periods of time. If these bacteria are present in large numbers on teat skin, it is the result of recent contamination from a source such as bedding. Thus, the number of these bacteria on teat skin is a reflection of the cow’s exposure to the contaminating environment.

One of the environmental factors that has the greatest impact on bacteria in the cows’ surrounding is the choice of bedding materials. The bacterial view of life apparently is very simple: eat, drink, and reproduce. Unfortunately, many materials used to bed dairy cows allow for bacteria to accomplish these meager goals with astounding proficiency. Many organic materials provide adequate nutrition for both coliforms and environmental streptococci to reach populations in excess of 10 million colony forming units per gram of bedding.

Common organic bedding materials such as sawdust and straw usually contain very few mastitis pathogens before use as bedding. However, mastitis pathogens that contaminate the cows’ environment establish residence in the bedding and often reach maximum populations within 24 hours after fresh bedding is added to stalls. The rapid increase in bacterial populations often preclude the soiled appearance of bedding. Therefore, the gross appearance of bedding has little correlation with bacterial load.

Bacterial populations tend to remain constant for up to 7-to-10 days, then start to decline due to the exhaustion of nutrients in bedding. The common practice of adding “fresh” bedding to stalls or manure packs replenishes the essential nutrients and maintains bacterial populations.

Particle size of bedding influences bacterial populations. Finely chopped materials support greater bacterial numbers than the same bedding with larger particle
areas where temperatures are seldom
lots are used primarily in hot, arid
Midwestern and Eastern herds. Dry
lots differ from those of traditional
herds where cows are maintained on
Climatic factors affecting exposure in
moderate the effects of heat and humidity
ventilation of barns is essential to
bedding and both ambient temperature
correlation between bacterial counts in
Previous trials have shown a strong
weather and increases as temperatures
in housing areas.

sizes. Finely chopped organic material
has greater surface area for attachment
and colonization by bacteria.

For example, chopped straw generally
has higher counts than long straw, sawdust greater than shavings, and
chopped newspaper greater than shredded paper. In addition, finely
chopped materials adhere more readily
to teat skin than larger materials, thus
increasing exposure of the teat end to
mastitis pathogens.

Growth rates of coliforms and environmental
streptococci are greatest during warm, wet
weather. The effects of season on bacterial
populations in bedding are quite dramatic in
regions that experience a wide variation of
temperatures within a year. In general, the
impact of bedding on exposure of cows in
confinement housing decreases during cold
weather and increases as temperatures
and humidity increase.

Previous trials have shown a strong
correlation between bacterial counts in
bedding and both ambient temperature
and relative humidity. Therefore, proper
ventilation of barns is essential to
moderate the effects of heat and humidity
in housing areas.

Climatic factors affecting exposure in
herds where cows are maintained on
dry lots differ from those of traditional
Midwestern and Eastern herds. Dry
lots are used primarily in hot, arid
areas where temperatures are seldom
below freezing for an extended time. In
these areas, the rainy seasons of late Fall
through early Spring are when bacterial
counts of pathogens are greatest. Manure in
dry lots during the Summer tends to be
desiccated, thus limiting the moisture
essential for bacterial growth.

The Cow's View
Much like bacteria, the primary goals of
a cow are to eat, drink, and to continue
propagation of the species. The latter
of these is an environmental factor that
greatly affects the incidence of mastitis.

Parturition, lactation, mammary involution,
and lactogenesis (initiation of milk
secretion) are each reproductive events
that influence the susceptibility of the
mammary gland to infection. Rates of
new intramammary infections caused by
environmental streptococci and coliforms
are greater during the dry period than
during lactation. During the dry period,
susceptibility to intramammary infection is
greatest the two weeks after drying off and
the two weeks prior to calving.

Many infections acquired during the dry
period persist to lactation and become
clinical cases. Research has shown that
65% of coliform clinical cases that occur
in the first two months of lactation are
from intramammary infections (IMI) that
originated during the dry period.

Streptococcal infections during the dry period
account for 56% of clinical cases during
the first two months after calving. Rate of
inframammary infections during lactation
is highest at calving and decreases as
days in milk advances. (Figure 1.)

Therefore, the thrust of herd management
strategies for controlling environmental
mastitis should focus on reducing
inframammary infections during the dry
period and early lactation.

Housing and other environmental
concerns for dry and maternity cows
often are precluded by the comfort and
housing needs of lactating cows. However,
given the impact of intramammary
infections acquired during the dry period
on the subsequent lactation, providing
cows with a clean and dry environment
is not limited to during lactation.

Dry cow and maternity facilities should be
managed similar to lactating cow housing.
Dry cow areas should be well drained
and free of excess manure. Dirt covered
areas can expose cows to pathogen levels
comparable to those in free stalls. Box
stalls and loose housing areas should be
cleaned to the foundation base regularly.
Manure packs are to be avoided because
they generally contain extremely high
counts of pathogens dangerous to both
dam and calf.

Bedding Management
The bedding material that we recommend
most for controlling environmental
mastitis is washed sand. Ideally, bedding
should be inorganic materials that are
low in moisture content and contain few
nutrients for bacteria to utilize.

Washed sand has little nutritive value
to common mastitis pathogens, thus
limiting their growth. Washed sand
consistently contains fewer mastitis
pathogens compared with organic
materials such as sawdust, recycled
manure, straw, and dirt.

On-farm separation sand from manure
by mechanical devices or passive
settling in ponds has gained popularity
as a means to reduce hauling charges
and allow the recycling of sand.
Care must be taken to assure the
reclaimed sand has minimal organic
contamination. A rule of thumb is
the ash content of sand (estimate of
organic load) should be below 3% for
use as dairy cow bedding.

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Many free stall barns are forced to use organic bedding materials that are compatible with liquid manure handling systems. There appears to be little advantage in using one organic material over the use of another.

For example, straw tends to have highest streptococcal counts, while sawdust and recycled manure have highest coliform counts in comparisons among these bedding materials.

Recycled manure bedding has regained popularity as dairies strive to be more ecologically responsible by separating manure solids and installing methane digesters. Recycled manure solids often have bacteriological properties similar to those of sawdust when used as bedding. Composting and heating recycled manure and sawdust can initially reduce bacterial populations before use as bedding, however these treatments have minimal effect on reducing teat end exposure after 24 hours in free stalls.

Any material to be used as bedding should be stored in a dry area to prevent saturation by rain and ground moisture. Composting organic materials such as manure is an effective way to reduce bacterial counts before use as bedding. However, although many organic bedding materials have relatively few mastitis pathogens prior to use, the pathogen populations often increase 10,000-fold within a few hours when used as bedding.

Fresh bedding tends to absorb moisture from the cows’ environment for use by the great number of bacteria that are constantly present in manure and soiled bedding.

Regardless of the bedding used, removing wet and soiled material from the back one-third of stalls will significantly reduce the bacterial counts. Stalls should be raked a minimum of twice daily when animals are moved to be milked. Spraying bedding with disinfectant and adding powdered lime or conditioners to bedding have met with little practical success in reducing bacterial counts.

These practices cause an initial decline in bacterial populations, but pathogen numbers quickly recover. Twice a day application of powdered lime may be necessary to sustain an advantage in lowering bacterial numbers. Avoid standing water and mud in free stalls, holding areas, and corrals.

Dirt and manure covered corrals are commonly used to house cows in semi-arid and arid areas. Exposure to pathogens generally is low during the dry seasons as moisture content of the dirt-manure mixture is low.

However, as density of cows increase under shade structures and around feeding areas and water troughs, excess wet organic matter should be removed or spread out to be dried. Cows’ access to dirt-manure lots should be limited during rainy seasons. Outbreaks of coliform mastitis are common during rainy seasons when cows are exposed to dirt-manure lots and alleys leading to the milking parlors.

Conclusions
An old, but popular, mastitis cliche is that environmental mastitis control is based on keeping cows clean, dry and comfortable. While this is true, the other half of the mastitis equation must also be accounted. Mastitis pathogens must be kept cold, thirsty and hungry.

Engineering decisions and husbandry practices should consider the importance of maintaining cow comfort and a healthy immune system while simultaneously minimizing pathogen populations in the environment.
A new science referred to as Nutrigenomics, which has emerged as a result of significant developments in genetic research, is evaluating the role of some non-traditional nutrients in maintaining a healthy immune system. Through the use of microarray technology, we can now study the impact of nutrients on specific genes and their genetic expression. Subtle changes in animal diets can “turn on” or “turn off” specific genes responsible for cellular health. This gene regulation in turn impacts the overall health of the animal.

Nutrigenomics is now making its way out of laboratories and onto the farm, where improved knowledge about the role of dietary nutrients in activating gene expression is having an impact on herd health and productivity.

Prince Agri Products has harnessed these key, scientific findings from this revolutionary new science through its Gen-Active Technology platform and is using it to develop innovative nutritional products designed to support normal animal health.

A healthy immune system is paramount in protecting dairy cows against bacterial pathogens while reducing a wide range of diseases associated with these pathogens.

**The Immune System of Ruminants**

The immune system in the dairy cow consists of two distinct but interactive systems. The innate system is comprised of natural barriers (skin, stomach acids, enzymes, etc.) and white blood cells (neutrophils and macrophages) which continually monitor for sites of infection and pathogens and are the “first responders.” The adaptive or antibody system consists of other types of white blood cells whose function is to provide “long-term” protection against disease through the production of pathogen-specific antibodies.

**Benefits of a Properly Functioning Immune System**

The benefits of a healthy immune system are many, and include reduced mastitis and metritis, lower somatic cell count, less death loss and culls, better reproductive efficiency and increased milk production. Proper management and good nutrition can help reduce the occurrence of disease in your herd, which can result in lower treatment costs and more days spent in profitable milk production, which can increase your total dairy income.

**Estimated Economic Impact of Disease**

<table>
<thead>
<tr>
<th>Disease</th>
<th>Average $/case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastitis (a)</td>
<td>$300</td>
</tr>
<tr>
<td>Metritis (b)</td>
<td>$285</td>
</tr>
<tr>
<td>Abortion (a)</td>
<td>$200</td>
</tr>
<tr>
<td>DA's (a)</td>
<td>$340</td>
</tr>
<tr>
<td>HBS (c)</td>
<td>$2500</td>
</tr>
<tr>
<td>Dead Cows (c)</td>
<td>$2500</td>
</tr>
</tbody>
</table>

[c] Estimated Replacement Costs

It is far more important and cost effective to promote health, by maintaining a healthy immune system, than it is to treat disease.

Maintaining a healthy immune system is one of the dairy producer's most economically rewarding management tools.