The Effects of Dust Particles in Equine Upper Respiratory Diseases

by

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In partial fulfillment of
the requirements for
the Alfred University Honors Program

May 9, 2019

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Preface

From the time I was 12 years old, I knew that I always wanted to become a veterinarian in which I could treat and work with horses as much as possible. Horses have been a huge part of my life. When I got into horseback riding, the most logical thing for me to do was join our local 4-H group, where I learned of my love for equine science. Throughout my 4-H career, we were required to go through a checklist of requirements to be able to show horses at the county fair every August. Those requirements involved various presentations and academic competitions based on the knowledge of horses, from grooming and everyday care to medical treatment. As I got older, the competitions focused more on the science and medical care of horses, from learning the structure and conformation of the horse to specific diseases and how to treat them.

After obtaining basic knowledge about several types of medical issues with horses, the main issues I found to be extremely common and interesting were heaves and difficulty breathing. The severity of each case varied from horse to horse. Some horses cases were so severe that they had to stop working until their breathing returned to normal while others could go their whole lives with minimal problems once the ailment was under control. I also found it interesting that these two symptoms can be connected and can have a large impact in a horse's daily life.

Over the years I've moved around from boarding facilities and found that almost every barn that I went to had dealt with one or more of these medical issues. When I asked the owners and barn managers about what the cause could be, I was told that its allergies or the change in weather. At the time, these reasonings made sense. I was

always told that heaves can be a symptom of certain allergies and if severe enough, can cause the horse to have issue breathing.

Throughout my high school career, I looked up basic causes for these ailments and found that one of the main causes was exposure to dusty and moldy hay. I've read and heard over the years that the main thing to help horses with these problems were basic breathing medicines such as "Air Power" or Ventipulmin Syrup, which help with airway obstructions, as well as soaking hay to minimize dust particle intake. With regular doses of these types of medications, horses should be able to live comfortably and perform with little to no trouble whatsoever.

However, it wasn't until I started riding for Alfred University's Intercollegiate Horse Show Association (IHSA) Team at the Bromeley-Daggett Equestrian Center that I noticed how severe some cases can be. Throughout my 4 years riding for the team, I found that several horses would have such a hard time breathing and that over time their symptoms would get worse. They would get to the point that we would have to stop riding and working them in practice or not use them at all. Some horses would go weeks without being worked because they had such a hard time catching their breath, which took a toll on everyone: the horses, coaches, teammates and caretakers.

At the time, I couldn't figure out why some of these horses were having so many issues with regulating their breathing, even with medications being given daily or prior to each ride. This went against the basic knowledge I had on the topic. In the equine industry, most people learn how to handle medical issues and problems as they come, and build their knowledge based on what they learn on a daily basis, or through the basic competitions done through any local 4-H or equestrian club around the area. For

most people, that basic knowledge was to treat the problem, never to eliminate the cause. I felt that these reasons weren't all the pieces of the puzzle. But what was alarming was that although the medicine helped at times, it generally never brought full relief to the horse, and in some cases, it didn't help the animal at all.

This gave me the idea to do more research on the topic. I wanted to learn more about what caused heaves and airway obstruction in horses. I wanted to see if steps had been made to try and determine what the cause is and what the proper way of handling these problems based on the environment the animal is in. How much research has been done on this specific topic? How many substances or irritants can cause such a problem? Are there ways to eliminate mold and dust from hay? Which one of these treatments is best? Or even how to stop this problem from emerging?

With these questions in mind, I began to start my research with a basic literature search, reviewing several different journal articles, studies and even reviews about how I could link all these ideas and be able to answer the bigger question at hand, why horses commonly develop heaves and respiratory problems. After looking at several different studies, I found that there is no straight answer in how to prevent horses from developing these problems or to at least minimize them. There were several articles on Equine upper respiratory diseases and how they link to the environment in which these animals are exposed. There were also several different articles talking about different methods of testing the horse's environment and how to know what treatments are best. These variations can be due to several different factors: age of the study, how the environment was tested, what instruments were used, and how the basic environment was laid out.

Researchers tended to face other difficulties, one of the most obvious is the lack of numbers in each study. Although there are several horses that have these common diseases, it's hard to be able to get them to all to the same location and determine if that specific location or the variables being tested will have an effect on the horse's upper respiratory tract. Some hay types may be more susceptible to dust, or the stable that they are kept at might be older or have more dust than others (which can have an effect if the horse isn't normally exposed to these environments). Some horses may be more susceptible to dust exposure than others, or they may have had the disease longer than other horses in the study.

After reviewing all the previous research done, I was able to start piecing together my own study. What I found that was interesting was the variability of the equipment used in several different studies, as well as the types of feed and environments. There were very few articles that had relatively the same environment, which made it slightly difficult to compare and see how their results varied.

This research shows that there are alternative ways to help horses besides consistently pumping drugs and other medicines into their system. These changes include adjusting cleaning methods, turnout times, and adjusting their feed program. These alternative ways may not only help horses mask their symptoms, but can help minimize them and potentially decrease the amount of medicines they are taking.

Changing a horse's feeding routine is one of the most essential practices when it comes to treating upper respiratory diseases. This type of change consists of observing hay for dust and mold and treating it. There are several methods when it comes to treating hay, the two most common methods are soaking hay in water and steaming it.

When soaking hay, you place it into water for an extended period of time and shake it out before feeding it to your horse. This method allows the water to clean out the dust and mold before the horse ingests it. Steaming hay does a similar task. The hay is placed into a “chamber” and steamed for an extended period of time, eliminating the dust and mold while maintaining the nutrient levels in the hay. Both of these methods have been shown to help aid horses as well as potentially helping owners use dusty and moldy hay instead of getting rid of it.

Another method that can help keep a horse’s respiratory system healthy is making their facility as dust free as possible. This can be done by increasing ventilation in a barn, limiting the amount of sweeping and increasing the amount of turnout for horses. Increasing ventilation (such as opening window and doors) and decreasing the amount of dust circling in the barn can drastically improve the air quality.

Increasing turnout can also help with the amount of dust a horse breathes in by placing them in an open outdoor area with fresh air. If horses get more turnout on a regular basis, it can help decrease the amount of time these animals are exposed to dust and keep them happier overall. Being placed on turnout also helps with the feeding aspect. Horses that get turned out on grass more often will potentially need less hay, which limits the amount of dust and mold they are exposed to.

With these topics in mind, my goal is to learn and understand the ins and outs of upper respiratory diseases and the best ways to help treat them and allow horses to live more comfortably. Upper respiratory diseases are becoming more frequent. Several of these problems can be temporarily solved through basic treatments and medicine. If people want to treat their horse for long term success, owners should learn to check

and treat their hay as needed and to adopt proper and ideal turnout, and barn cleaning situations for these horses. There is more research that needs to be completed when it comes to understanding hay steamers and their results. Several studies have shown that hay steamers combined with better air quality are the best type of care when it comes to treating horses with upper respiratory diseases.

Introduction

Equine upper respiratory diseases are the most common types of diseases in horses, especially for horses kept in barns for long periods of time. One of the most common types is Recurrent Airway Obstruction (RAO). RAO is caused by the buildup of dust and mold in the respiratory system. RAO can't be fully cured and if the disease is severe enough, it can cause a horse to be in constant distress and lead poor performance in the future. However, there are several ways to help ease the horses' pain and discomfort. The most common method for treating the symptoms of this disease is to administer steroids and other medications.

Although RAO can be temporarily masked with basic medications, a horses' symptoms never seem to fully go away or decrease in severity when treated in this manner. There are several methods and practices used to help minimize the symptoms of RAO. This can be accomplished by first developing an understanding of the equine anatomy and obtaining basic information on upper respiratory diseases. Once that is established, a person must look into the main methods to eliminate dust and mold from a horses feed and prevent them from inhaling these microbes. Once that is established, the hygienic quality of your hay should be tested before purchasing it and by using

equipment such as hay steamers or soaking the hay. Limiting the amount of dust inhaled by the horse can be done by increasing a horse's turnout and improving the air quality in the barn. If all of these methods are implemented when treating a horse with RAO, it will not only relieve horses of the symptoms, it can improve their quality of life and increase overall health.

Equine Upper Respiratory and Digestive Tract

The upper respiratory tract consists of the nasal cavity, nasopharynx, trachea, right and left bronchi, lungs, main bronchi, bronchiole, capillaries and alveolus (Figure 1). Air goes through the nose and nasal cavity on the head, to the nasopharynx and trachea, which starts at the back of the head. The trachea travels down the horse's neck where it connects to the right and left bronchii. From there, air travels into the lungs to the main bronchii and flows through the bronchiole, capillaries and alveoli (Morris, 1991).

When looking at the respiratory tract, it is important to ensure that the airway isn't being compromised, especially by airborne dust particles. When dust enters the airway, it can cause mucus to build up in the lungs and make breathing difficult, which reduces the amount of oxygen available for the horse. Several diseases can also cause this buildup of mucus in the lungs which will be discussed in a later section (Morris, 1991).

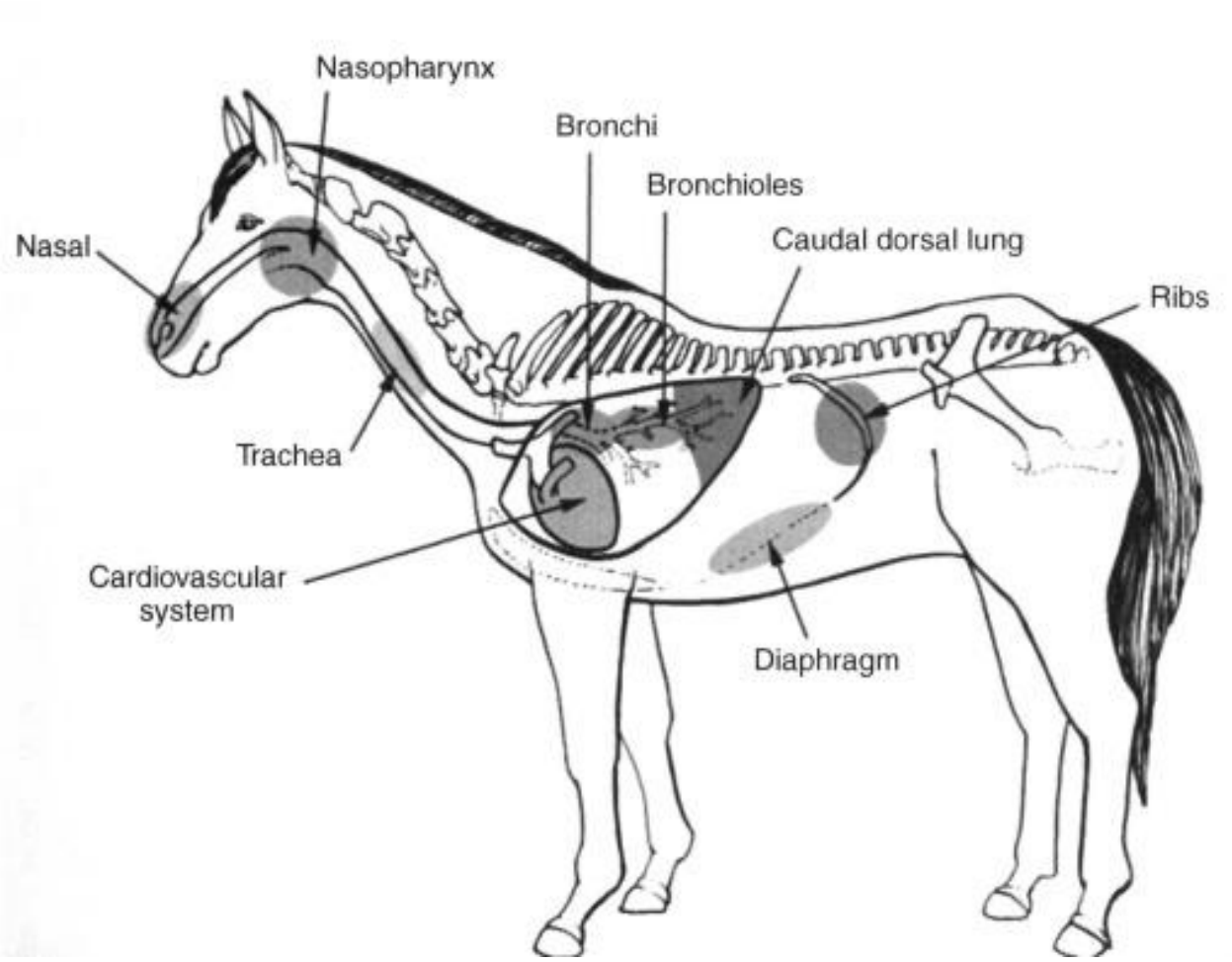

Figure 1: Diagram of the Equine Upper Respiratory Tract. Adapted from "Poor Performance and Field Evaluation of the Respiratory System" Veterinary Clinics of Northern America: Equine Practice, 589-600. Copyright 1997 W.B Saunders Company.

When looking at the type of hay that needs to be fed, it is important to have a basic understanding on the anatomy of the digestive tract. Horses are hindgut fermenters, which means their hay is degraded in the caecum and colon while proteins are mainly degraded in the small intestine. According to Figure 2, Their digestive tract starts with the esophagus, which leads to the stomach. From the stomach, the digestive tract leads to the small intestine then the large intestine, which is made up of the caecum and the colon, and the rectum. The stomach takes up about 8% of the digestive tract, which is small compared to their size. The small intestine takes up about 30% and

the large intestine takes up about 62% of the digestive tract. Each section of the digestive tract is separated by valves, which limit the amount of feed that is allowed to enter at each point. After a horse ingests its feed, it will reach the cecum and colon after about 3 hours. The feed enters the caecum through a valve that connects the ileum of the small intestine and the caecum (Dicks et al., 2014).

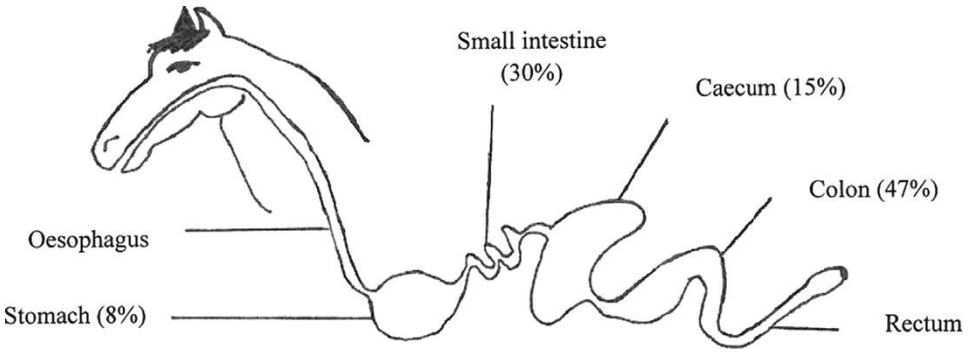

Figure 2: Equine gastro-intestinal tract. Adapted from "The equine gastro-intestinal tract: An overview of the microbiota, disease and treatment". Livestock Science, 69-81. Copyright 2013 Elsevier B.V.

To digest nutrients, specifically in the cecum of the large intestine, the body uses specific anaerobic bacteria and protozoa to break down nutrients and cellulose from hay or grass. The most dominant types of protozoa in the gut are *Streptococcus lutetiensis*, *Streptococcus equinus* and *Bacteroides spp*. The main type of bacteria that breaks down cellulose in the cecum of the horse is *Ruminococcus flavefaciens*, which is followed by *Fibrobacter succinogenes* and *R. albus* (Dicks et al., 2014).

Upper Respiratory Diseases

One of the most commonly known diseases associated with dust exposure is heaves, also known as Recurrent Airway Obstruction (RAO). These are diseases that effect the function of the upper respiratory tract in horses and can be most prevalent in

horses that occupy the northern hemisphere. It is a medical problem that develops when being confined to stalls and constant exposure to dusty and moldy hay (Ainsworth et al., 2003). Heaves is a chronic disorder of the airways commonly found in equine facilities around the world. It is known to effect approximately 10-20% of adult horses. When a horse contracts this disease, their resting respiratory rates increase, and they show signs of excessive coughing and exercise intolerance. There is no permanent treatment for heaves but there are a few ways to help minimize the symptoms and make the horses more comfortable. The use of corticosteroids can provide rapid relief for the horse, but if the exposure to dust isn't controlled, the coughing and high respiratory rate will continue to occur (Leclere et al., 2011).

RAO is characterized by bronchial hyperactivity which is the contraction of small airways, pulmonary neutrophilic, which is build up of neurophils in the blood and excessive mucus production. When dust, fungal and bacterial spores accumulate in the system, it causes mucus to build up in the airways and cause an obstruction (Ainsworth et al. 2003).

Clinical signs of RAO can range from exercise intolerance to dramatic respiratory distress. These signs are caused by the resistance to airflow in the lung due to bronchoconstriction. The disease is relatively mild until the horse shows the clinical signs while at rest. Horses with this disease also show signs of coughing, nasal discharge, increased respiratory effort and weight loss if the case is severe enough. Respiratory distress in these "heavy" horses is shown by the increased nasal flaring and increased abdominal contractions. When exhaling, there is a forced prolonged exhalation with a rapid collapse of the thorax and then an exaggerated abdominal lift

known as a “heave-line” occurs (Leclare et al., 2011). Horses with signs of RAO also tend to show signs of an increased lung capacity and increased bronchovesicular sounds, which are sounds that occur between the bronchi and alveoli. They also show signs of crackle noises at the periphery of the lung (Leguillette, 2003).

Environment

Environment plays an immense role in a horses’ underlying health. Just like with any living species, if the quality of their environment decreases, then so does their health. Air quality and habitat are major portion of the environmental conditions. In equids, an inadequate environment can lead to poor performance and RAO in race horses and show horses. Since horses were originally meant to live on the open plains, heaves is regarded as a disease of domestication (Leclere, 2011).

The conditions of horses have changed dramatically over time. Horses went from being free range animals to domesticated ones and then brought from the open land to closed in or limited pastures and barns. There are three common types of living conditions or environments for domesticated horses: living outside permanently with a shelter, stalled in a barn with monitored/limited turnout and stalled with no turn out (Buechner-Maxwell et al.,1996). When horses lived in the open plains, air exchange was continuous and exposure to respirable dust and debris was minimal. Since being in closed or limited quarters, the exposure is more frequent (Buechner-Maxwell et al.,1996).

With the domestication of the horse, owners and exhibitors have taken their care to the extreme. People who own performance horses tend to keep them inside due to

fear of injury or getting marked up by other horses, As well as if any type of medical issue prevents the horse from staying sound or healthy. Several performances horses are known to develop problems with lameness, such as when the navicular bone in the horses' hoof or the ligaments are damaged. It has been found that horses develop respiratory problems after developing lameness (James et al., 2009).

Airborne dust is generally composed of different sized particles of plant fragments, as well as mites, bacteria, mold spores, yeasts and endotoxins. When horses are kept inside a barn every day, they can be exposed to dust and fungal spores coming from various sources. Respirable dust can come the bedding used in the stalls. The level of composition of these particles is influenced by the type of bedding, forage and general horse care activities. When inhaled, these dust particles can travel in the respiratory system down to the alveoli. Particles that reach this point are generally around the size of 5µm or less and consist of fungal spores, such as *Aspergillius app*., *Thermophilic actinomycetes (Thermoactinomyces vulgarism* and *Saccharopolysora rectivirgula)*. First time exposure to these microorganisms won't cause any major effect, it's repeated exposure (Auger et al., 2017).

Barn owners tend to use the American Barn System (AB), which has poor air ventilation when the barns are closed up (Auger, 2017). The clearance rate of dust depends on the amount of proper ventilation in the barn. Bedding generally made from pine tree shavings can cause dust when moved and transported throughout a stable when cleaning stalls. This dust then settles and is stirred up again as the horses move around. Caretakers also tend to clean other aspects of the barn, such as sweeping isle ways and brushing off horses covered in dirt. According to Stokes Law, dust particles

can remain in the air for extended periods of time. So, when dust particles are agitated or unsettled due to sweeping or moving objects around the barn, dust is lifted up and floats in the air for extended periods of time. When a barn is swept, settled particles of dust are agitated, causing them to spread throughout the air. If the barns are closed up (which is common in the winter time), then the dust isn't able to travel outside of the barn, causing the particles to circulate inside and either be inhaled or ingested (Auger, 2016).

To manage RAO in horses, limiting the amount of dust present in their environment is essential (Miskovic et al., 2007). Horses that are turned out regularly have less of a risk of contracting upper respiratory diseases due to the "break" or shared time between the pasture and the stall. If the barn doesn't allow proper ventilation, horses are able to get quality air without airborne particles when on turnout. Horses housed like this can be considered hobby horses, or even some type of show horse. (Buechner-Maxwell et al., 1996).

The standard AB system allows for horses to openly share air space which can have a negative impact on their respiratory health. There are several methods of stabling besides the AB System. Such as the single stable method, That is known for slightly better air quality. In this setting, the stalls are only roughly 3.6x4.2m in size and air isn't shared with other horses. In both settings, airspace is restricted by the height of the barn (Auger et al., 2016).

Type of Hay Used and Hay Analysis

Good quality forage is the basis of horse feeding. Horses are hind gut fermenters, which allows them to properly digest the fibers found in grass and hay. Their diet roughly consists of three-fourths hay or alfalfa and one-fourth grain. Grain isn't fed in high quantities due to the limited amount of starch needed in their diet. If the amount of starch consumed is too high, it can cause horses to colic or even cause laminitis and ulcers.

Fermentation in the hind-gut allows the horse to digest cellulose and fiber in the cecum, which is located in the large intestine. Digestion starts with the mastication of grain or forage in the mouth, then the food content goes to the stomach where protein and fats are broken down. The stomach also kills microorganisms reducing the risk of infection. Nutrients are then absorbed in the small intestine, which is about 60-70 feet long and consists of the duodenum, jejunum and ileum, and eventually enters the bloodstream after they are absorbed. The remaining contents of enter the large intestine, which is composed of the cecum, colon and rectum. The cecum is fairly large in the horse and can hold a significant amount of fibrous material that needs to be broken down by microorganisms, such as cellulosic bacteria, fungi and yeasts. Fibrous material comes from the hay and grass that horses consume on a daily basis. Contents left over from the cecum then make their way through the ceco-colic junction to the colon (Van Weyenberg et al., 2006).

There are several types of forage that can be used in equine nutrition. Some of the most common types of species are *Trifolium repent, Lolium perenne, Alopecurus geniculatus, Poa trivialis* and *Holcus lanatus* (Sequin et al., 2010). The production of hay is tedious, due to proper timing of weather. Dry storage during harvest is crucial to

achieve and maintain quality of hay to avoid mold growth. If mold growth isn't avoided then it could end up in a horse's upper respiratory tract and cause RAO (Bergero et al. 2011).

When looking at a situation like this, there are several methods of dust and fungal spore elimination, but which one is best? To start, equestrians should find a way to reduce air contamination from their bedding forage and other sources. To do that, it is important to have background on where the hay is harvested and test the hay currently being used (Bergero et al., 2011).

Of all these factors that can affect hay quality, the maturity when it is harvested is most essential. As grass begins to grow from a vegetative to a seed stage, the plant increases in fiber content and decreases in protein content. Other important factors when looking at hay quality are the concentration of neutral detergent fibers or acid detergent fibers, which measures the structural component and energy in specific plant cells. These characteristics are all important to the nutritional value of hay (Bergero et al., 2011).

These factors are why many are switching to different forms of hay, known as haylage and silage. Haylage is harvested in a later stage of maturity compared to forages (Schenck et al., 2014). Haylage is similar to silage, which is a type of grass that's compacted and stored in a silo but has a dry matter content that exceeds over 500g DM/kg. It is packaged in large bales, doesn't trap dust and is high in nutritive vales. The downside to haylage is that it is rather expensive and doesn't improve digestibility. However, the use of silage and haylage has become more prominent and widespread (Bergero et al. 2011).

Grasslands are a major importance in the agro-ecosystem when it comes to livestock nutrition. When looking at forage for harvesting, it's important consider the agricultural practices used, such as the height of the hay when its cut, tossing of the hay and density of it, as well as the type of forage. Some hays and haylage tend to have a higher dust and fungal concentration. If these practices are carefully selected, they can potentially help to reduce the dust accumulation in hay as well as the fungal count and limit the amount of respiratory damage in horses (Seguin, et al., 2010).

Since haylage is harvested so late, it can be associated with the risk of impaired hygienic quality and a short aerobic storage stability once the bale of hay is open. Proper hygienic quality in hay is when the hay is dry and dust free with minimal to no dust or debris incased inside the hay. This would make it low quality because forages that are late harvest have been reported to have a higher number of microbes, such as bacteria and fungi (Schenck et al., 2014).

In order to properly determine the quality of hay, visual and chemical analyses can be performed; such as visual and chemical analyses. A visual analysis of hay is when an individual observes the quality. People generally look at the maturity of the hay, noted by the presence of leaves or stems. Leaves on hay generally determine that it isn’t mature and is in an early bloom stage, while hay that is more mature and in full bloom generally has little to no leaves and more stems. They also look at the color of the hay. Colors can range from green, yellow and brown. When hay is green this is the best quality of hay. If hay is more yellow, it tends to be more mature or potentially over mature, causing the hay to be less palatable and potentially wasted by most horses. When hay is brown or black, this is an indicator that the hay was wet and exposed to

humid environments. It also shows an extremely high amount of mold growth. Buyers also tend to check the odor of the hay to look for mold and or dust (Nadeau, 2006).

When looking at the chemical analysis of hay, most buyers tend to send samples out to specialists in forest crops. This analysis will generally consist of a Dry matter content (DM), Digestible Energy (DE), Total Digestible nutrients (TDN), crude protein (CP), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Nonstructural Carbohydrates (NSC). DM allows for determination of the moisture and dry matter content of the hay. An ideal amount of dry matter is around 89%. DE is the gross energy of the feed and is measured in mega calories per pound (Mcal/lb) and the amount depends on how much work the horse does on an average daily basis. Hay can have a range of 0.76 to 0.94 Mcal/lb or higher. TDN is the sum of the digestible fiber, protein, lipids and carbohydrates in the feed and is measured in its energy value which can range from 40 to 55%. CP measure the protein concentration of hay and can have a range of 6-8% in grass hays and 15% in higher quality legume hays. NDF is the measure of fiber concentration of the hay as a percentage and ADF is the measure of the fiber concentration of the hay as a percentage. NSC are measured in percentages and depend on the type of hay fed. Timothy and alfalfa can have between 15-20%. Starches and sugars shouldn’t be more than 15% of the total daily calories. All of these values may differ if a horse has any sort of medical issue (Nadeau, 2006).

One of the main things to look at is the dry matter content of both the hay and haylage. It was found that bailing, cutting and harvesting brings up the largest amount of dust in hay and haylage. When hay is bailed at low dry matter of 75%, it significantly increases the amount of total dust by 2 and 3-fold compared to hay bailed at higher dry

matter contents. Seguin et al., also found that the dustiness of hay is more prominent in less humid environments. When bailed at 85% dry matter, there is a decrease in the amount of breathable dust. When haylage is harvested, it tends to have a lower amount of dust particles than hay by 50 to 100-fold (Seguin et al., 2010).

When looking at the fungal content of airborne dust of these treatments, their density varied greatly. Mold and fungi tend to multiply between cutting and harvesting hay due to high moisture content. This is one thing that needs to be carefully balanced since a higher moisture content is of prime importance when it come to the quality of the hay (Seguin et al., 2010). It has also been found that after bailing certain forms of haylage, wrapping it in multiple layers of plastic for storage help decrease the amount of breathable dust and fungal spores (Seguin et al., 2010).

Methods of Treating Hay for Dust

When looking at treating hay in a barn, there are two methods that are commonly used: soaking and steaming. Both of these techniques are designed to eliminate the airborne dust (ABD) concentration and fungal spores in the hay. This can drastically decrease the symptoms of RAO.

The treatment method that has been around the longest is soaking hay. Prior to feeding, hay is generally stuffed into a hay net and then placed in a container or tub full of water for an extended period of time, which can range from 30 minutes to a couple hours prior to feeding (Moore-Coyler et al., 2016). Soaking hay for 30 minutes can reduce the ABD particles by 88%. However, when hay is soaked it can also leach out valuable minerals, such as potassium, sodium and phosphorous and carbohydrates

(Blackman & Moore-Colyer, 1998). Bacterial concentrations in the hay can also increase by 1.5- to 5-fold. 30 minutes is the ideal time to obtain the largest amount of ABD particle loss and the smallest amount of mineral loss. Overall though, soaking causes the quality of the forage to decrease (Moore-Coyler et al., 2016).

Steaming hay is a relatively new treatment method that has been introduced to the equine industry and is rapidly becoming a more acceptable alternative to soaking according to Blackman and Moore-Colyer (1998). They're several ways to steam hay: store hay in a hay net and place it in a plastic container or dustbin with a kettle element at the bottom to release steam or use specifically designed hay steamers, such as Haygain steamers (the Haygain models 1000 and 600). Hay steamers are proven to be the most effective of the two treatment methods (Moore-Colyer et al., 2016).

Steaming hay has become the more popular method in eliminating dust particles because it doesn't decrease the mineral and crude protein content of the hay, keeping the quality of the hay higher compared to the method of soaking. Blackman and Moore-Coyler (1998) found that soaking hay was less effective compared to steaming and that even while under the 30-minute timeframe, soaking hay still had a significant loss in nutrients such as sodium, potassium and phosphorus. Steaming, on the other hand, showed little to no loss in minerals.

James (2009) showed how a Haygain hay steamer successfully reduced bacteria and fungi counts in hay and improved the hygiene quality of whole bales of hay. English Rye grass was steamed for 50 minutes in a Haygain steamer and showed a 100% reduction in fungi content and a 98.54% reduction in viable bacteria in the hay.

Moore-Coyler et al. (2016) compared several different methods of reducing ABD particles: soaking hay and 3 different steaming techniques. Using a Haygain steamer (model 600) and soaking eliminated the same amount of ABD particles at 99%. The bacterial concentration when using the Haygain 600 steamer reduced by 99%. There were no reductions in nutrient content between dry and steamed hay when using a Haygain steamer. These nutrients included were crude protein calcium, magnesium, sodium, phosphorous, copper, nitrogen potassium and zinc. Overall, the Haygain 1000 steamer proved to be the most effective in reducing dust and maintaining the nutrient quality of the hay.

Haygain Steamers

Depending on the model of the Haygain steamer used, it can hold a few flakes of hay to a whole bale. The steamer has two components, a steam generator and an insulated chest. The steam generator heats up water to produce the steam needed to treat the hay. The steam escapes from this section of the steamer and travels through a multilayer construction hose and is distributed evenly throughout the hay chest. The lid of this steamer has a thermometer on it that reads the atmospheric pressure inside the chest to ensure that the lid is closed properly and that the hay inside is fully secured in the hay chest (James et al., 2009).

The most effective form of treating a horse’s symptoms would be to treat the hay with a Haygain steamer for each meal, while having proper ventilation unit in the barn and providing horses access to the outdoors 24/7 weather permitting and having knowledge on where and when your hay was cut, what the maturity of it is and how wet

the ground was when it was cut and bailed. The Haygain steamers reduce the amount of airborne dust particles at a higher percentage compared to soaking and wetting hay, while turning out horses more often and having proper ventilation reduces the amount of dust that the horse breathes in without consuming it. If a horse is in for some medical or weather predicament, minimizing the disturbance of dust by not sweeping or shaking out hay in the barn can help reduce the
amount of time the particles of dust float in the air and get breathed in by the horses.

Techniques Used to Sample Dust and Mold Concentrations in Hay

Gregory and Lacey in (1962) sampled a liberated hay dust cloud with a cascade impactor to examine particles though a microscope. A cascade impactor measures the range of a particulate or substance as it moves through the air. They also used an Anderson's sampler to properly identify organisms that were in the hay culture.

More recent studies have used several different dry-air particle separation technologies to measure the different ABD particle and mold concentrations (Garlipp et al., 2010). One of the most common types of ABD samplers is a cyclone dust sampler. This technology allows removal of dust particles and mold spores from the air by using vortex separation instead of a filter to trap the dust. The cyclone sampler is generally hung 1 meter from the floor and turned on for an extended period of time, generally around 3 mintues, to collect dust (Moore-Colyer et al., 2016);(Auger, 2017).

Recent studies have also used specific models of aerosol monitors (Clements et al., 2007), which are compact portable laser photometers that measure and record ABD

particles. They can measure aerasols in a wide variety of environments. This machine has often been paired up with a cyclone pre-classifier or sampler and Tygon tubing to help localize the area. The sample of dust goes through the cyclone sampler and passes through a sensing chamber where light with a wavelength of 0.78μm from the aerisol monitor measures and records the amount of dust particles in the sample (Clements et al., 2007). This method can also be used to enable the sampling of hay from the breathing zone of the horse. This can be done by attaching the aerosol monitor, cyclone, and Tygon tubing to the horse's head. The hay is then measured for dust concentration in the same way, but done from the perspective of the horse to see how much dust is in the air they breathe (Clements et al., 2007b).

Medical treatments of RAO

When looking at all the different variables that account for causing Recurrent Airway Obstruction in horses, there are several ways to best accommodate the lifestyle of the horses and their owners. Combining the methods of barn care, horse care and the feed they eat, can drastically reduce the symptoms of RAO and potentially increase the performance levels of the horses affected by it.

There are several types of medications that can be used to treat RAO, which results in a horse's airway to become "blocked" or inflamed, causing severe inflammation. One of the main types of medications is a corticosteroid. Drugs from the steroid family work by binding to cellular glucocorticoid receptors in the bronchial and vascular epithelial cells. This binding results in a cascade if events that lead to the release of cytoplasmic NF-κB which enters the nucleus of the cell and alters the

regulation of gene transcription leading to the inhibition of the synthesis of inflammatory cytokines (Leguillette, 2003).

The traditional approach to treating RAO with corticosteroids is to use a systemic administration approach. According to Leguillette (2003), several studies have shown that short term administration of corticosteroids doesn't cure a horse with RAO or rid the horse of its symptoms. They found that doses of 0.1mg/kg to 0.05 mg/kg and 0.04 mg.kg of dexamethasone (type of corticosteroid) administered on a daily basis dramatically improves respiratory function in RAO affected horses. This treatment starts to work 3 days after the initial dosage, and by the 7th day of treatment, their lung function is almost back to normal. The same dose of dexamethasone is also proven effective when administered by and intramuscular route. However, if the horse is exposed to a constant dusty environment, the symptoms of RAO will continue to appear until they are removed it.

Although corticosteroids are supposed to be beneficial when treating RAO, the use of this drug can lead to major side effects in horses, such as the development of laminitis. Laminitis is the inflammation of the laminae (tissue) and the disruption of blood flow inside a horse's hoof. The laminae are the tissue that secures the coffin bone (wedge shaped bone) to the hoof wall. This inflammation, if severe enough, can cause the hoof wall and the coffin bone to separate and potentially lead to the coffin bone penetrating the sole of the horse's hoof (Leguillette, 2003).

This recommendation isn't always easy to follow due to the condition of the horse, the facility, and the program the horse is used in. Equestrians tend to board their horse because they don't have the means at home to keep them or have their horses in

a specific training program. Facilities tend to only do turnout for a couple of hours and aren't able to provide proper ventilation and the best quality of hay for all of their clients. It is important for the managers and trainers of these facilities to understand RAO and the best way for them to treat horses in their facility.

These facilities could ensure that a horse with RAO gets slightly more turnout compared to other horses and move them to a stall that is closer to a window or door for proper ventilation of air. In these situations, if the symptoms of RAO still occur and affect the performance and comfort of the animal, medications can be distributed for an as needed basis.

Conclusion

Upper Respiratory Diseases, such as RAO, are extremely common in domesticated horses. There are several factors to look at when trying to find the best plan of action when treating these types of diseases. They have to look at the structure of the barn and see how much ventilation it has, minimize the amount of sweeping or stirring up of dust when the barn is closed up on the colder days or winter months. People also have to look into the hay you are buying by doing a visual observation and getting information on when the hay was harvested and baled to ensure there is minimal dust. If that can't be controlled, there are other methods on how to treat hay such as soaking or steaming.

When looking at the best ways to help treat this disease and minimize the symptoms, there are several ways to accommodate the horses. Several of these problems can be masked with basic medications, but the most efficient way to minimize symptoms is to ensure that the horse has a massive amount of turnout and dust free

hay. If there are restrictions on turnout, such as medical conditions or being at a boarding facility where turnout is limited, owners can make sure the horse is are stalled appropriately where the best quality of air is and allow the dusty low-quality air to exit the facility. Medications can also be put into these rotations but on an as need basis, such as when the horses' symptoms are flaring up.

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