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Respiratory and General Health of Dairy Cows associated with Wildfires (a synthesis)

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Abstract

The respiratory health of dairy cows has a great importance for their general health status and their productivity. Respiratory health is impacted by many intrinsic factors as well as environmental factors. Poor barn climatic conditions and failing management, as well as heat stress conditions are examples of situations where-in the basic respiratory health is not optimal. Moreover, wildfires lead to situations where the basic respiratory health is further impacted. Wildfires occur every year and worldwide. The most important risk factors are the heat of the fire itself, the smoke of the fires which may travel large distances, the fine particles in the smoke and the chemical components in the smoke. Some particles are so small that they enter deeply into the lungs of the cows and cause damage there. In this paper, the basic respiratory health of cows is addressed, as well as the risk factors in housing and management contributing to this basic respiratory health, and the signs of a disturbed respiratory health associated with wildfires. If indicated, comparisons are made with the situation of human beings.

Keywords: Wildfires; Climatic Conditions; Respiratory Health; Yielding Cows; Heat Stress

Abbreviations: BRH: Basic Respiratory Health; AQI: Air Quality Index

Introduction

Good basic respiratory health (BRH) is important for a good general health status and good performance, especially in high yielding cows. These cows are quite comparable to top athletes [1-5]. A disturbed BRH has a negative effect because the oxygen exchange in the lungs is disturbed, while the immune responsiveness is reduced [1]. The BRH is influenced by factors such as the general health status of the cows, the management quality of the farmer, for example regarding the barn climate, the nutrition, and his management of heat stress [6], the quality of the air (pollen, particles, chemical components, gases related to wildfires).

The effects of heat stress and wildfires occur in the same season

Cows respire by their nose and eat their feed with their head low. When there are obstructions in their respiratory system, their respiration is hampered. Poor barn climatic conditions and poor air quality outside will lead to a situation where cows can no longer get rid of dust, particles, and micro-organisms from their respiratory system in a physiological way [3,4]. A BRH already disturbed will be affected even more when wildfires occur. The goals of this paper are to present (1) the characteristics of a BRH and the parameters to evaluate the BRH, (2) the signs of a disturbed respiratory function, and (3) discuss the various effects of wildfires on the respiratory health in dairy cows. Finally, management measures are proposed to limit the forenamed effects.

The basic respiratory health of dairy cows, and the air quality outside

BRH is defined as the physiological function of the body to exchange oxygen from the air to the lungs and blood circulation. This exchange function is influenced by genetic make-up of the cow, the general health status, the anatomical conformation, and different environmental factors such as farm management quality, and air quality. The heart frequency of a cow in rest is between 15 and 35 bpm, depending on breed, the level of metabolism and level of milk yield. When this frequency rises dramatically, there is a true problem. Air Quality is important. This quality concerns, among others, the level of air pollution, de concentration of pollen,

fungi spores, chemical pollution, and fine particles [7]. The [7] has developed and Air Quality Index (AQI) which is a parameter for air quality. This AQI considers various factors named in Figure 1. Furthermore, EPA has a large international network of institutions around the world from which data about air quality are sent to EPA and by which the AQI can be calculated per region [5]. In Figure 2 is presented a so-called *'easy to read'* infographic about AQI. It is generally accepted that, at an AQI of 300, man has an increased risk of respiratory and possibly other problems. Dairy cattle are less sensitive than man and their threshold value is rather around an AQI of 350 (in comparison: a sport horse would have that threshold value around 300 too). The individual, biological variation among men and among animals causes the fact that even at lower AQI there always be individuals who are more sensitive to the problems than others (see the triangle in Figure 2 for those individuals). Hence, the AQI is an indication, not an absolute value.

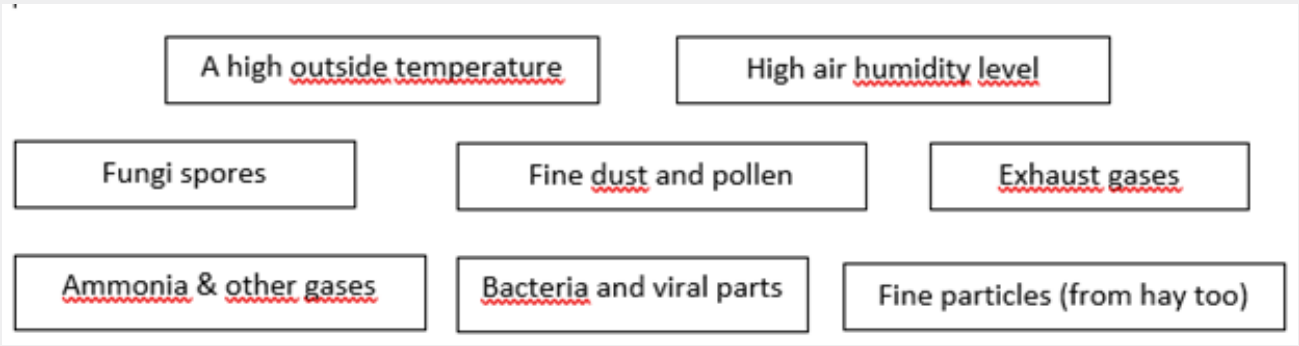

Figure1: Review of some important factors impacting Air Quality negatively [1].

Figure 2: Infographic of the AQI (Air Quality Index).

Source: [7].

As mentioned earlier, there are also other factors impacting respiratory health. These are the factors of housing the cows and the quality of farm management, addressing quality of feed, of drinking water, of hygiene [6]. When several of these factors together have a negative impact, the respiratory health will be impaired, and the cows are more sensitive to heat stress, social stress, and effects of wildfires [1]. Table 1 presents an overview of different parameters for checking the BRH in cows. When most of the parameters deviate from the target value, problems in barn climatic conditions and/or farm management will be present [1-4]. In Table 2 are listed the signs of disturbed basic respiratory health. These signs may also be observed in cows suffering from pain, in cows under heat stress conditions, social stress and or stress caused by wildfires. The parameters in Table 1 look a lot like the various factors causing respiratory disorders in man. However, in man much more factors are known, which are not

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applicable in dairy cows. Examples are tobacco use, chronic heart and/or pulmonary problems, cancer, body weight (obese), social status, allergies, educational level [8]. The Signs Listed in Table 2 are Comparable to those Observed in Man.

Table 1: Important parameters for evaluating the basic respiratory health in dairy cows.

Evaluation-parameters for risks of a disturbed basic respiratory health in cows	Remarks
Poor relative air humidity (RH) in the barns	Should be 60% to 70%
High ambient temperatures in the barns l (heat stress)	Standard is between 10˚C and 22˚C
Condensation, rust, rotten wood parts	Proves a too high air humidity
Bad odors in the barns	Ammonia, NH_3 (poor ventilation)
Insects and much dust in the barns	Irritation of cows; too much dust in hay
Draught in the barns	Stirs up dust and particles in the barn
Too few Air Inlets and outlets in the barns	Check number, positioning, volume
Fans are present or absent	Check number, positioning, capacity
Quality of flooring and litter in the barns	If humid/wet, there will be insects (soon)
Increased respiratory frequency	Dairy cow : > 35 bpm
Heat Stress	Temperature > 22˚C and RH > 70%

Table 2: The most pertinent visible signs of disturbed basic respiratory health in dairy cows.

Respiratory frequency is > 35 bpm
Cows show beating in the flanks
Cows respire with nostrils wide open
Frequent coughing
Eyes are irritated or with inflammation
Nasal discharge is often observed
Loss of milk production

Components in the air originate from wildfires and have effects on respiratory health in dairy cows

Table 3: Risk-conditions for the respiratory and general health of dairy cows (and men), associated with wildfires [9]

Component	Details	Remarks
The heat of the fire itself	Destruction of cells of the respiratory system	Gas burning leads to immune depression
Smoke and associated combustion materials	CO, CO_2, HCN, NO, NO_2, formaldehyde, H_2S, hydrocarbons, dioxin Formaldehyde, acrolein, benzene, soot Particles	These are all toxic gases and materials. CO and HCN are found close to the fire (firemen at high risk)
Fine particles < P 10_{micron}	In solid and liquid form	Severe respiratory problems
Ultrafine particles $P_{2,5micron}$ or even smaller ($P_{0,4 - 0,7 micron}$)	Enter deeply into the lungs	Cause cell destruction in the respiratory system
Airborne particles carried through the smoke	Carbon, sulfur, nitrogen, metals, chemicals	Are hazardous for health too
Cows refusing to eat	Because of smoke	Or smoke components
Cows refusing to drink	Leads to dehydration (mucosae!) in the respiratory system	As a result, toxic substances remain longer in the system

During wildfires many products are freed in the air, namely in the smoke. This smoke may be extended over large distances [9]. The composition of the smoke depends on the different types of wood, vegetation, plastics, construction material and other combustible material being burned [10]. All materials named produce a range of different (chemical) components when they burn [5,11]. The greatest threat for the respiratory health of dairy cows in prairies (and men) comes from fine and ultra-fine particles in the smoke [12]. Specifically, the particles $P_{10micron}$ and $P_{5micron}$) are dangerous. The $P_{5micron}$ enters deeply into the lungs [7]. To get an idea about the size of the fine particles, a human hair has a diameter of 60 micron. Table 3 presents an overview of different

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risk conditions for respiratory and general health problems in dairy cows (and man), as represented by components in smoke. The biggest problems are caused by droplets of liquid fine particles and solid fine particles in smoke. The particles $P_{2,5micron}$ (and even smaller ones) enter most deeply into the lungs and cause much damage there in tissue and cells. Note that ashes and soot in the smoke may cause irritation of skin, nose, eyes, throat, which is often accompanied by bleeding and frequent coughing.

Table 4: Examples of effects of smoke and its components from a wildfire on the health of dairy cows.

Irritation of eyes and respiratory system	Immune-depression
Generalized severe stress (Abortion in dairy cows)	Hypoxia leading to problems at the central nervous system (confusion depression)
Accelerated sighing; obstruction of air ways	Reduced visibility (desorientation)
Pulmonary function (severely) reduced	Burned skin, legs, eyes, and/or ears. Burned claws
Bronchitis, tracheitis	Inflammations
Frequent coughing due to fine particles	Burned teats
Difficult, whistling respiration	Mastitis
Pulmonary edema	Dehorned claws; infections
Nasal discharge	Coma and death

Table 4 presents the effects of smoke from wildfire on dairy cows. These effects are comparable to those listed in Table 2 for disturbed basic respiratory health (BRH). The smoke and its components are, hence, the greatest risk factors for disturbed respiratory health in dairy cows (and man). In all cases, the welfare of the cows is severely impacted. Decisive factors in wildfires which lead to a severely polluted air and a poor health status are the duration of exposition, the volume of air (smoke and soot) inhaled, the level of the individual health status (vaccination status, disease history, age) and the concentration of toxic components in the air (that is: smoke) [9]. Inhalation of smoke can rapidly cause hypoxia of the brains and the lungs [13].

Prognosis of a Potential Recovery

The prognosis for a dairy herd or cow depends first on the possibility and rapidity of evacuating that herd far away from a wildfire location to a healthy spot (or prairie) out of the wind and smoke. A universal protocol cannot be given here because it must be tailor-made to an individual farm. What about individual dairy cows? High yielding cows are more sensitive to wildfire effects of smoke and components than low producing cows. But both will be affected. Depending on duration of exposition and severity of a wildfire, especially the smoke and its components, and the general state of resistance and sensitivity of the animal, the prognosis of a potential recovery will vary [5]. For example, after light exposure, the recovery of a horse may take two to four weeks; for a dairy cow it might be comparable. But again, it depends on exposure and duration. If a chronic problem has been established in the meantime (for example after a severe and longtime exposure to fine particles entering deeply into the lungs), a recovery -if any- may take more than 2 months. Some cows develop chronic asthma and will undoubtedly be lost. Sometimes cows cannot be saved at all and die; other times cows show signs only one or two days after exposure to a wildfire of short duration.

Note that the halftime life of fine particles entering deeply into the lungs is about 90 days [5,11]. There is, hence, a residual effect. The effects of an immune depression become manifest much later. Effects of exposure on the long term have not been studied in dairy cows or have not been reported. Conclusion is that the long-term outcome is not predictable at all. As a result, it will not be easy for a veterinarian to speak about the prognosis for a cow affected by forest fire or its components.

Discussion and Final Remarks

i. Despite the biological differences between dairy cows and man, still comparisons can be made as is shown in the text. One big difference between species is that several studies on the sensitivity of man and about the effects of wildfires (smoke, gases, fine particles, chemical components, soot) on man have been reported in literature. Such studies on dairy cattle are unknown, or never reported. Another difference between man and dairy cows is that treatments are proposed for man but not for dairy cows, most probably because of the costs and the applicability. Man may escape from forest fire, dairy herds mostly cannot. An exception in treatment is maybe the rapid treatment called 're-oxygenation' of the genetically most valuable high yielding dairy cows in the herd. In the context of a Biosecurity Plan on a dairy farm, it would be advisable to develop a Protocol 'Wildfire Actions & Prevention', not in the least because fires are not limited to forest fires but may also occur inside buildings. The purpose of such a protocol is the awareness of prevention, for example an Action Plan for evacuation as part of a Fire Actions & Prevention Plan. The latter should be best developed together with the local fire brigade. It is out of the scope of this paper to elaborate these protocols here.

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