Equine asthma: managing the environment

Equine asthma is an umbrella term defined by nonseptic lower airway inflammation. Currently there are two broad categories, namely mild to moderate equine asthma (formerly known as inflammatory airway disease) and severe equine asthma (formerly known as recurrent airway obstruction or heaves). Environmental challenge is involved in the aetiopathogenesis of both these subcategories. Much of this challenge, and the part that we can control, is provided by the organic dust associated with the stabling of horses. This article reviews the available evidence relating to the environmental management of equine asthma and tries to relate this to practical options for providing a low-dust environment.

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The term equine asthma is used to describe nonseptic lower airway inflammation under a broad phenotypic definition that allows for multiple, potentially overlapping, subcategories of disease (Pirie et al, 2016). This umbrella term is designed to cover the diversity in aetiology, immunology, pathophysiology, genetics and clinical severity undoubtedly underpinning the disease syndrome; it is not a continuum. Currently we are restricted to two categories, mild to moderate equine asthma and severe equine asthma, these being predominantly differentiated by the presence at rest of increased respiratory effort in the latter (Couëtil et al, 2016). Mild to moderate equine asthma has previously been called inflammatory airway disease (IAD), while severe equine asthma has been known as chronic obstructive pulmonary disease (COPD), recurrent airway obstruction (RAO) and 'heaves'.

Severe equine asthma's clinical signs, ranging from poor performance to coughing and expiratory dyspnoea, can be attributed to lower airway inflammation induced by immunological responses, including hypersensitivity, to airborne organic dust. A myriad of different agents present in a horse's stabled environment can contribute to the aetiology of this disease, with moulds having a principle role along with endotoxins (Pirie et al, 2003; Pirie, 2014). Horses with severe equine asthma have increased airway reactivity, thus non-specific stimuli such as other particulates and irritant gases, for example ammonia, may exacerbate or prolong clinical signs (Pirie, 2014). Severe equine asthma is generally associated with stabling, which is unavoidable in many situations or climates, especially during winter. However, not all severe equine asthma is associated with housing, as recognised in the subset of equine pasture asthma (formerly summer pasture associated obstructive pulmonary disease), where inciting agents have been suggested to be pollens and fungal spores in association with heat and humidity (Costa et al, 2006; Bullone et al, 2016). The management changes discussed in this article will not be of direct benefit to such horses, but removal to a low-dust housed environment is a standard recommendation.

The link to housing is less clearly defined for mild to moderate asthma, and much is extrapolated from severe equine asthma, but there is growing evidence identifying the association of airborne challenge with the disease (Holcombe et al, 2001; Ivester et al, 2014; 2018; Dauvillier et al, 2019).

Housing fundamentally provides a challenge to any horse's respiratory tract, principally via dust and endotoxins (McGorum et al, 1998; Berndt et al, 2010), with airway inflammation being induced in otherwise healthy horses (Holcombe et al, 2001; Robinson et al, 2003). If housing is unavoidable it can be argued that the aim should be to reduce challenge, whether or not disease is present. The extensive environment should be considered as well as the horse's immediate environment, namely its breathing zone (*Figure 1*) (Woods et al, 1993; Berndt et al, 2010; Ivester et al, 2012). An 'equine personal cloud' effect helps conceptualise the challenge to an individual horse, as it is used to describe the microenvironment immediately surrounding the horse, with particulate concentrations being determined by ambient particulate levels and particulates generated or resuspended by the horse's activity (Ivester et al, 2012).

Non-specific irritant stimuli or potential allergens, which can remain suspended in air for prolonged periods and can penetrate deep within the lung impacting on the epithelial surface, are termed the respirable fraction and are broadly considered to

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be less than 4–5 µm in diameter (Clements and Pirie, 2007a), for example *Aspergillus* spp. spores are 2–4 µm. The respirable fraction appears to be an important determinant in the type and degree of airway inflammation in racing Thoroughbreds (Ivester et al, 2018). The pulmonary defences of epithelium, cilia and mucus exist to protect against such particles, but perhaps not the overwhelming challenge imposed by horse domestication.

After diagnosis, pharmacological therapy is often employed to provide rapid symptomatic relief while measures are put in place to reduce respiratory challenge: the primary goal of long-term management. However, in some instances where the respiratory stimuli cannot be fully eliminated, then greater reliance on pharmacological control may be required, often in anticipation of challenge. Management changes aim to create a low-dust environment to ensure severe equine asthma remains in remission while in mild to moderate asthma it should lead to resolution in most cases, although continued effort to maintain good air hygiene makes sense. This article aims to review practical management of equine asthma using the available evidence where possible; it should be noted that evidence for the relative impact of management changes can be hard to compare and extrapolate to clinical situations, as the experimental conditions and materials used vary greatly. Pasture turnout is ideal, but when housing is unavoidable it presents a multifactorial, cumulative challenge to the horse's respiratory tract. Factors are considered under the broad categories of forage, housing, bedding and management practices, although a holistic approach is always required.

Forage

It is generally not possible to avoid the exposure of horses to forage at some point of the year, and forage is constantly within the breathing zone when fed, irrespective of how well ventilated a stable is. Hay should be preserved with a dry matter content of greater than 85% in an attempt to reduce fungal and microbial growth. However, hay is often baled and stored with a higher than desired moisture content and has long been recognised as a source of organic particles and specifically allergens, such as *Aspergillus fumigatus* spores, that may induce severe equine asthma in susceptible horses (McGorum et al, 1993; Pirie et al, 2002). Hay soaking is a common method to reduce respiratory challenge, with full immersion for 30–60 minutes generally being accepted to sufficiently reduce mould and dust particles, including breathing zone respirable particles (Blackman and Moore-Colyer, 1998; Clements and Pirie, 2007b); damping or wetting of hay is not generally acceptable. Short-term soaking will lead to some leaching of nutrients, minerals and vitamins, but more prolonged soaking, useful for managing obesity and related conditions, will cause far greater loss (Mack et al, 2014; Argo et al, 2015). It should be confirmed that owners are soaking hay correctly, as a significant proportion may not do so (Hotchkiss et al, 2007a). To aid compliance, advice can be given as to practical methods of soaking hay, such as wheelie bins fitted with a drainage hole (*Figure 2*) or the widely available commercial hay soakers. It is important that hay does not subsequently dry out and release respirable particles during feeding.

Steaming hay is one alternative, as it significantly reduces respirable particles but with less nutrient loss compared to soaking, while maintaining, or increasing, palatability (Blackman and Moore-Colyer 1998; Moore-Colyer et al, 2014; Auger and Moore-Colyer, 2017). However, the steaming method is likely to be important as commercial products have been demonstrated to achieve greater reductions in respirable particles, as well as bacterial and mould concentrations, than DIY methods (Moore-Colyer et al, 2016). This superiority has been attributed to the design of some commercial products ensuring delivery of high temperature steam to all parts of a hay bale. The impact of steaming, as for soaking, will also depend on the hay type and its quality, for example in terms of mould concentration, as well as the disease status of the individual horse (Earing et al, 2013). Horses fed steamed hay have been shown to have reduced likelihood of being diagnosed with mild to moderate equine asthma (Dauvillier et al, 2019). In contrast, another study identified that while steaming significantly decreased mould content, the feeding of this hay to severe equine asthma affected horses was associated with respiratory inflammation, such as elevation of neutrophil proportion in bronchoalvelolar lavage fluid (Orard et al, 2018).

Complete hay replacement fibre pellets have been used effectively to control equine asthma (Woods et al, 1993; Derksen et al, 1999). In the author's experience, these are not practical long term solutions for many horses if used as a complete feed replacement, in terms of palatability alone, but they can be valuable as supplementary feeding when a horse is principally managed at pasture (Leclere et al, 2012).

How forage is fed has been shown to have some impact on the respiratory challenge. Feeding hay from the floor can provide less respirable challenge than using nets (Ivester et al, 2014). One hypothesis is that horses' muzzles are commonly buried in the hay when pulling it from a net, thus the nostrils are in close proximity to the particles released by such agitation. In contrast when feeding from the ground the breathing zone is above the source of particles and a degree of sedimentation and diffusion may occur reducing exposure. However, in a later study, using hay nets hung outside open fronted stables provided a similar challenge to feeding from the floor; perhaps this practice both prevented horses from burying their breathing zone in the nets and encouraged them to spend more time with their heads outside the stall (Ivester et al, 2018).

Haylage has become a common forage in the United Kingdom (Hotchkiss et al, 2007a). It is a strong alternative to soaking or steaming hay in equine asthma management, with good quality haylage having lower concentrations of allergens and other respirable particles (Kirschvink et al, 2002; Séguin et al, 2012; Siegers et al, 2018). Cutting haylage at the correct time to achieve a dry matter content between 50–70%, before then baling with sufficient wrapping to create airtight conditions, will prevent unwanted fungal and bacterial growth due to the anaerobic environment, while the higher moisture content compared to hay reduces dust (Harris et al, 2017). Although there will be some fermentation, this is limited compared to that required for silage, which has a lower dry matter content, in which acidity is key to preservation. Haylage avoids the labour involved in soaking or steaming hay. Even if horses are not symptomatic, sub-clinical respiratory inflammation, and even airway remodelling, may continue when soaked or steamed hay is fed (Orard et al, 2018). There is some evidence, and from this author's experience, that for some asthma affected hors-

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Figure 1. Illustration of the breathing zone of a horse.

Figure 2. A converted bin used for soaking a bale (or less) of hay. Note the brass drainage hole bottom right.

es such methods are insufficient to cause clinical remission, due to a failure to reduce allergen load, with this only being achieved by a switch to haylage (Dixon et al, 1995a; 1995b). A disadvantage of feeding haylage is that for horses with obesity and related problems, its feeding will often be inappropriate (Carslake et al, 2018).

Bedding

Straw exposure is associated with equine asthma; combined with dry hay it is regularly used in experimental designs to induce clinical signs in susceptible horses (Holcombe et al, 2001; Leclere et al, 2012). Evidence as to benefit is sparse for some types of low-dust bedding and it is hard to compare between the studies that have been published, largely because of variations in the preparation of similar bedding types. Dust-extracted shavings are widely used and are effective in managing horses with asthma (Woods et al, 1993; McGorum et al, 1998; Vandenput et al, 1998). Paper and cardboard can be effective alternative beddings (Thomson and McPherson, 1984; Tanner et al, 1998; Ward et al, 2001; Kirschvink et al, 2002), although they can be problematic in terms of 'littering' a yard and its surrounding area. Other products such as wheat straw pellets and hemp based products are available, but it is hard to identify strong evidence that they are equivalent to, or superior to, shavings or paper (Fleming et al, 2008). It is often recommended that deep litter systems should be avoided, as they are likely to generate higher levels of airborne endotoxin and mould contamination, but evidence is sparse. Often rubber mats are used in conjunction with bedding; this has the advantage of reducing the quantity of bedding required. Depending on how a bed is maintained, this may reduce the likelihood of a deeper bed generating endotoxins and moulds or prevent the build-up of ammonia concentrations.

Housing

The effect of housing cannot be disentangled from forage or bedding, and when these have been addressed it should be ensured that ventilation is effective, otherwise respirable particles will remain in the air for long periods (Auger and Moore-Colyer, 2017). What constitutes an efficient stable design is beyond the scope of this article. Open-fronted stables with ventilation to the rear are one simple design solution, while barns with internal stables and a shared airspace can be more problematic. Careful consideration has to be given to the ventilation of these structures, including making use of the stack effect; that is, warm air rising and exiting via a roof outlet, drawing in fresh air from lower level inlets (*Figure 3*). One study did not demonstrate a significant difference in airborne respirable particles between single stables and American barns (Auger and Moore-Colyer, 2017). Ventilation at the horse's breathing zone should be considered, so if feeding from the floor then air movement at this level is important. It should be ensured that ventilation points, including windows, are open at all times throughout the year. Keeping barn doors open has been shown to decrease the concentration of airborne particles less than 10 µm in size (Ivester et al, 2012). Season may also have an impact on the challenge posed by being housed, with particulate levels being higher in barns in summer compared to winter, perhaps due to lower average wind speeds in summer as well as the effect of am-

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bient heat on ventilation (Millerick-May et al, 2011; Ivester et al, 2012; Auger and Moore-Colyer, 2017). Not all these studies were performed in the UK, but they do suggest that the best place for a horse in summer is at pasture.

Drainage within stables will play a role, with organic waste fluid, including urine, accumulating in certain areas of stables or underneath rubber mats, leading to high levels of ammonia and other noxious gases, and even promoting mould growth within bedding. Forage and straw storage should not be within the same air space as horse stabling; if stored above stables it should be sealed from the horses below. Muck heap location has to be considered, as these have the potential to generate considerable quantities of organic dust and other airborne irritants. These need to be remote from stables, including the ventilation points.

Management practices

However well a housed environment is managed to control equine asthma, it is preferable that stabling should be kept to a minimum by the use of turn out to pasture. Respirable, total particulate and endotoxin levels measured in the breathing zone at pasture have been shown to be significantly less than when a horse is stabled in a low-dust environment (McGorum et al, 1998; Berndt et al, 2010). An association between severe equine asthma, diagnosed by owner questionnaire, and time at pasture demonstrated that the benefit of turn out during winter may not be appreciated until the duration is greater than 15 hours per day (Hotchkiss et al, 2007b). Non-pasture turnout, such as outdoor ménages, will also be beneficial, as long as surface dust is considered. If simple changes have failed to control equine asthma then some owners may even elect to change premises if livery yard management practices limit, for example, winter turn out.

If dietary supplementation is required when a horse is at pasture then careful consideration should be given to how, and what, forage is used. This includes that provided to field companions and adjacent fields if feeding areas are shared. Pelleted feeds may be a good option in these circumstances (Ivester and Couëtil, 2014).

While housed, all organic dust sources should be kept to a minimum, and logically this would apply to all horses in the shared airspace. There is evidence supporting extending minimal dust regimens to all neighbours (Clements and Pirie, 2007b; Auger and Moore-Colyer, 2017) although this may not always be necessary (Jackson et al, 2000). On livery yards this will require cooperation with all stakeholders; if discussions are not productive then moving premises is again an option. Further cooperation is required to ensure that horses are absent from their stable when it, or its neighbours, are mucked out, as this presents a considerable challenge; particulate levels vary greatly with activities within a building (Clarke, 1987; Millerick-May et al, 2011; Ivester et al, 2012). For the same reason horses should be groomed outside. All bucket feeds should be dampened, as these can generate airborne particles within the breathing zone (Hessel et al, 2009). How a horse is travelled is worth considering, as the consequent elevated head position has been shown to cause transient respiratory inflammation (Allano et al, 2016). Lack of yard biosecurity is a remote risk, but respiratory viral exposure is known to be associated with human asthma exacerbation, and even its aetiology (Oliver et al, 2014). Equine studies have suggested similar links with mild to moderate asthma (Houtsma et al, 2015).

Management of equine pasture asthma

In equine pasture asthma, environmental challenge is outside of our control (Costa et al, 2006; Bullone et al, 2016). Geographically relocating an animal is one option but more realistic is its removal from pasture into a low-dust environment, this may be partially beneficial. These cases can be challenging, as horses may also suffer severe equine asthma due to housing challenge (Mair, 1996). Prophylactic medical therapy to control the disease may be required.

Summing up

The use of straw bedding and dry hay produces high levels of airborne respirable dust in stables, in particular in the breathing zone, and cannot be recommended for any horse (Auger and Moore-Colyer, 2017), let alone performance horses (Dauvillier et al, 2019). A recent systematic review provided strong evidence that environmental management methods aimed at reducing dust exposure should be used in the treatment of severe equine asthma (Ivester and Couëtil, 2014). The same review gave a similar recommendation for mild to moderate equine asthma, but based on moderate evidence (Ivester and Couëtil, 2014).

With severe equine asthma, if no changes are made to the environment then prolonged exposure will lead to airway remodelling and eventually irreversibly impaired lung function (Herszberg et al, 2006). Even when horses with severe equine asthma are maintained in low-dust environments, or at pasture, they may continue to have residual peripheral airway obstruction due to structural changes (Vandenput et al, 1998; Miskovic et al, 2007). Although prolonged antigen avoidance over 12 months did decrease airway remodelling in one study, there were indications that some remodelling could be refractory to intervention (Leclere et al, 2012).

In severe equine asthma affected horses there can be a reduction in clinical signs, or even remission, in days to weeks following managemental changes, but the timescale will depend on age, and severity or duration of the disease (Thomson and McPherson, 1984; Jackson et al, 2000). Response to management changes may also depend on individual horse's behaviour when stabled, as this may influence the quantity of dust inhaled — their own 'equine personal cloud' effect (Ivester et al, 2012).

Conclusions

The environmental management of equine asthma can be straightforward when there are easily identifiable, modifiable respiratory challenges, such as changing from dry hay to soaked hay or haylage. However, other cases are more challenging, where major modifications have already been adopted and close scrutiny is required to identify marginal gains in environmental management, with the cumulative benefit of these gains being required to ensure disease control. If a horse continues to be refractory to management, and medical treatment, then it is prudent to revisit the diagnosis and consider alternative diagnostic hypotheses. EQ

Conflicts of interest

The author has no conflicts of interest to declare.

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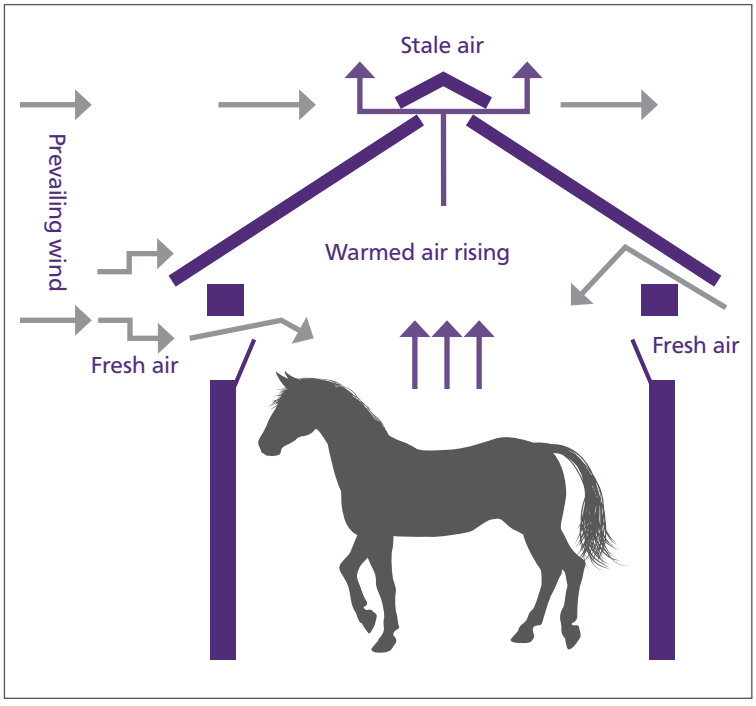

Figure 3. Schematic diagram illustrating one example of passive, or natural, ventilation using the stack effect.

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KEY POINTS

- It can be argued that all horses, not just horses with equine asthma, should be stabled in a low-dust environment that is well ventilated.
- For most equine asthma affected horses the optimum goal is to maximise turnout to pasture, but where this is not possible a holistic approach to all aspects of the environment should be pursued.
- Attention should be paid to what respirable particles are present in the breathing zone of a horse.
- In some cases soaking or steaming hay may be suboptimal and good quality haylage may be a more robust solution.
- Bedding and ventilation are critical to consider, the latter for removing the remaining respirable dust that may be present in the environment as well as other irritants such as noxious gases.
- The finer details of management should be considered to minimise dust exposure, from the horse not being present when their stall is mucked out to grooming outside.

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