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S2.1

Effects of Litter Moisture on Performance, Health and Welfare

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Litter moisture can have a potent impact on bird health, welfare and performance. These effects are mediated through direct contact dermatitis from poor quality litter, through to exacerbation of respiratory disease from poor air quality and food safety issues associated with soiled birds being presented for slaughter. Losses can be due to infectious disease or downgrading at processing, whilst the welfare effects relate to insults to skin integrity and the respiratory tract. Increasingly, it is likely that welfare outcome indicators such as the incidence of footpad dermatitis and hock burn will be used to assess animal welfare under a variety of growing conditions, as a proxy measure of on farm litter conditions and bird welfare. Reducing the impact of the contributing factors requires effective stockmanship, including management of drinker and ventilation systems, the use of high quality feed and targeted disease control and biosecurity measures.

Keywords: litter quality, wet litter, footpad dermatitis, pododermatitis

Introduction

Successful poultry production in Europe depends on efficient and profitable performance in systems that at the same time allow the fullest expression of the birds' welfare wants and needs. The effective balance between production efficiency and welfare is clearly dependent on a whole range of management, husbandry and environmental factors. In floor based systems, it is the litter substrate underfoot that is one of the most important influences on successful performance and bird welfare, especially in broiler chickens and meat turkeys. Good quality litter supplies comfortable bedding which holds and maintains moisture, and works to neutralise unwanted microbial activity from faecal material whilst providing a source of warm and dry material underfoot. Good litter also supplies a substrate which enables the birds to satisfy their ethological needs in promoting dust bathing.

So how can good litter be defined?

Council Directive 2007/43/EC (*laying down minimum rules for the production of chickens kept for meat production*) requires that "All chickens shall have permanent access to litter which is dry and friable on the surface" (Annex 1). The requirements of this Directive are currently being transferred into UK legislation, although current domestic legislation already encompasses many of these requirements. For example, the Welfare of Farmed Animals (England) Regulations 2007 state that "Keepers must ensure that poultry are kept on, or have access at all times, to well maintained litter or a well drained area for resting" and the Welfare Codes require that "Litter should be kept loose and friable" and "should also be inspected to ensure it does not become excessively wet or dry" (Codes of Recommendations for the Welfare of Livestock: Meat Chickens and Breeding Chickens: DEFRA.)

These legislative requirements appear to concentrate on the moisture content and the texture of the litter and place great significance on its friability. Friability relates to the ability to reduce a solid substance into smaller pieces with little effort (Wikipedia 2009). In terms of poultry litter, this requires it to be firm in the hand but it should not be caked and sticky. It should fall apart when dropped. These attributes help to ensure that the litter "works". Litter that breaks up easily when birds busk and scratch aerates the substrate, allowing moisture release enabling its removal by natural or controlled environment ventilation systems. The aerobic conditions also promote aerobic microbial activity that generates heat for comfort, which itself accelerates water release from the litter and encourages breakdown of organic material deposited with faeces.

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Other definitions of good litter relate more specifically to its moisture content. Although there are no specific guidelines it is generally accepted that good litter is considered to be that with a dry matter content of 65 to 75% and may be described as "wet" when this falls below 45%. The impact of wet litter on performance and welfare depends on aspects other than just absolute water content. It may also be related to the distribution and extent of poor litter across the house, for example is it just under drinker lines or more widespread? The adverse impact of poor litter may be further heightened by diarrhoea or the presence of abnormal or poorly digested watery droppings.

Thus, it is a combination of water content, its distribution across the poultry shed and the nature of any abnormal droppings that may have other adverse characteristics such as extremes of pH or other irritant or caustic components. Capping or caking of litter runs the risk of trapping moisture and noxious gasses (especially ammonia) underneath the litter surface, preventing the litter from truly working and contributing to litter "burns" of the parts of the bird coming into contact with the litter surface, notably hocks, footpads and in severe problems, breast skin.

Litter substrates that achieve the goal of supplying "good litter" must be absorbent, lightweight, non-toxic, non-tainting and inexpensive. Wood shavings are one of the most popular substrates due their high moisture absorption properties but also allowing moisture release to minimise caking and capping. Litter depth at placement will depend on the insulating properties of the shed and experience of the stockman as to effect this has on friability under different conditions. It is advisable to use the shallowest depth of shavings that works in a particular situation. Availability of good quality shavings can be related to the wider economy in terms of the amount of house building taking place. When shavings are scarce straw or chopped straw shavings mixes become more popular, with barley straw being favoured over wheat straw due its absorptive properties, although there is a risk with all straw substrates that microbiological contamination from mould/fungal growth (eg *Aspergillus*) or vermin spoilages (eg *Salmonella*) can lead to biosecurity breaches. Other substrates that are used include sawdust, rice hulls, pine, shredded cardboard and other fibres; their choice being influenced by availability, local preference or house type.

What are the causes of wet litter?

Most observers agree that the causes of wet litter are many and varied, but can be broadly divided into infectious and non-infectious factors. However, it is equally clear that there is seldom one isolated cause and that the syndrome or condition of "wet litter" is most usually a combination of a range of interrelated factors – a true multi-factorial problem (Lister 2006). This complexity can make it difficult to unravel the causes and then implement control or preventive strategies. For instance, high stocking density has been associated with an increased incidence of footpad dermatitis (McIlroy *et al* 1987) but it is not clear whether this is due to increased faecal output/m², less efficient ventilation at high stocking rates, or changes in bird activity. It is likely to be a complex interaction of all these, and other, factors.

Non-infectious causes of wet litter

a. Water in, water out

Water quality can have a significant effect on water and feed intake and bird health. The value of clean water is often overlooked and it is important to consider the total bacterial count, pH and mineral content of the water supply.

The major source of water in the poultry house is the drinking water, although surface water ingress from the environment can contribute in specific situations. Poultry feed contributes very little to this. As a result drinker design and management are extremely important in maintaining good litter. Many workers (e.g. Bray and Lynn 1986, Ekstrand *et al* 1997) have demonstrated that closed nipple systems reduce water splashing onto the litter compared with other systems, especially the traditional open bell drinkers. However, drinker systems of whatever design can cause wet litter if they are badly maintained (excessive leakage) or poorly managed (e.g. wrong water pressure or set at the wrong height for the growing birds, leading to loss of water onto the litter at drinking). Even well managed open water systems may also contribute water directly to the house environment through evaporation from the bell drinker or trough.

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Another significant factor affecting drinking behaviour is ambient temperature. At around 20°C water consumption is usually considered to be about double the feed intake (ie 1.7 to 2.0:1, water:feed consumption). At 26°C this will probably rise to 2.5:1 and at 35°C 5:1. Therefore as ambient temperature increases so does water consumption which will lead to increased water output, either as evaporative loss through panting or directly onto the litter with increased faecal output of higher wet matter content. Where temperatures are high then there may be an increased drying effect from the litter, but this is very dependent on the efficiency of the ventilation system. Effective heat and water loss from a poultry house via controlled environment or natural ventilation systems is crucial for bird comfort and the balance of water input and output from the house. This can be related to the quality and management of a mechanical system but is influenced by climatic considerations, notably relative humidity of incoming and outgoing air. (Payne 1967). This is in turn influenced by ambient temperature with air becoming saturated with water (>70%) in summer months, but very inefficient water holding properties in cold winter temperatures. High quality management and attention to detail are crucial at different seasons of the year and if there are significant day/night variations, in enabling sufficient moisture removal from the house and the prevention of condensation effects. The temptation to compromise on minimum ventilation to conserve gas usage is usually a false economy and can lead to significant problems in maintaining adequate air exchange, water removal and hence litter quality.

b. Dietary effects

This topic has been reviewed on many occasions by many authors (e.g. Collett 2006). Problems have been related to physical feed quality, consistency and presentation together with a number of ingredient issues. Some of the more important factors include:

- 1 Physical effects – grit size, dust content, consistency and feed interruptions
- 2 Heat treatment of feeds for microbial control may have an adverse effect on digestibility
- 3 Electrolytes (eg potassium, sodium and chloride) affecting ionic balance, associated with formulations or feed ingredients (e.g. soya)
- 4 Protein – level, source, quality and digestibility
- 5 Fats – digestibility and effect on faecal quality and output, often contributing to greasy capped litter
- 6 Cereals – effect depends on digestibility and their effect on gut microflora
- 7 Mycotoxins – a variety of mycotoxins have had attributed a number of non-nutritive effects

Infectious causes of wet litter

It is outside the scope of this paper to describe all the possible infectious causes of wet litter, enteritis and intestinal disturbance. However, a variety of agents have been associated with gut disease and a wider variety of factors can upset the normal microflora of the intestines. Undoubtedly, the situation of gut homeostasis has deteriorated following the EU ban on the use of antimicrobial digestive enhancers (so-called growth promoters) in both broiler and turkey production. The most important infectious agents contributing to wet litter would include:

a Parasites

- 1 Coccidiosis
- 2 Hexmatiasis
- 3 Trichomoniasis
- 4 Cochlosoma

b Bacterial challenge

- 1 Clostridial infection – e.g. Clostridium perfringens and Necrotic enteritis
- 2 Dysbacteriosis – imbalance of bacteria within the gut
- 3 Other anaerobes
- 4 Spirochaetes e.g. Brachyspira spp.

c Viral infection

- 1 Gumboro disease
- 2 Infectious bronchitis – certain strains
- 3 Astroviruses
- 4 Rotaviruses
- 5 Enteroviruses

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What is the impact of poor litter on performance and welfare?

Good litter has the capacity to act as a reservoir for water in the house environment, holding or releasing that water as necessary. This water can be derived either directly from the drinking water system or following its transit through the bird via faeces (normal faeces has about 80% water content), or in a more limited way through sensible water loss through panting. Excessively wet or caustic litter can have significant direct and indirect effects on performance.

The most important direct effects are in terms of potential contact dermatitis of litter on the foot pads, hocks and breast skin, or through noxious gaseous effects on the eyes and respiratory tract (Berg 1998). Indirect effects relate more generally to air quality, for example, dust levels, air humidity and ammonia levels that can influence the incidence and severity of respiratory tract damage in combination with infectious disease (Reece *et al* 2000, Terzich *et al* 1998). Good air quality is essential in reducing the likely impact of infectious diseases such as mycoplasma, bacterial (e.g. *Ornithobacter rhinotracheale*, *Pasteurella*, *Haemophilus spp.*) and viral (e.g. avian pneumovirus, infectious bronchitis, ILT, Newcastle disease, avian influenza etc) infections.

Poorly working litter can also increase the microbiological load in the litter exposing the bird to increased challenges from parasites such as coccidia, other protozoa, environmental bacteria (coliforms, spirochaetes etc) and a range of enteric viruses.

An inability to effectively dust bathe can give rise to increased external parasite burdens and dirty feathering. Excessive soiling of feathers and skin can give rise to public health concerns through bacterial loading (eg *E.coli*, *Salmonella* and *Campylobacter*) at processing if soiled birds are presented for slaughter.

Litter conditions can have a significant impact on skin integrity (Martrenchar *et al* 2002). Wet or caustic litter leading to contact dermatitis or "burns" can allow a breach in the skin surface resulting in a range of bacterial lameness issues. On the other hand, excessively dry litter is frequently associated with an increased incidence of scratches and skin tears in birds that are excessively active. This can lead to downgrading at processing due to skin trauma and major lesions or through the condition known as skin necrosis in parts of Europe and infectious process or IP in the USA (Norton 1997, Norton *et al* 2000, Gomis *et al* 2002). In this condition the skin damage allows a range of bacteria to set up subcutaneous infections that are often not detected in birds on farm but can lead to severe financial loss at processing (Norton 1997).

All these insults can have an adverse effect on bird health and welfare. Furthermore it is likely that in wet litter situations there is a loss of the insulating effect of the litter and an inability to effectively dust bathe, both having negative welfare impacts on such birds.

Overall, the most significant effect on health, welfare and economics is in relation to the effects of contact dermatitis (Bruce *et al* 1990, Menzies *et al* 1998). Assessment of the welfare impact of different rearing systems for farm animals has historically focused on welfare inputs (eg stocking density, provision of feeders and drinkers etc) but increasingly attention is turning to welfare outcomes.

In this way, the true impact of a system on animal welfare can be better assessed and interpreted. Indeed, in the early drafts of Council Directive 2007/43/EC (Laying down minimum rules for the protection of chickens kept for meat production), it was recommended that, for broilers at least, assessment of the incidence of foot pad dermatitis (a condition resulting from contact dermatitis) be used as such as welfare outcome indicator.

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Consideration of the aetiology of foot pad dermatitis (pododermatitis) is useful in assessing the impact of litter quality on bird welfare and performance. Pododermatitis is inflammation of the foot pad leading to hyperkeratosis, erosive lesions and eventual ulceration of the sole of the foot. A whole variety of factors have been implicated as trigger factors including direct dietary influences on skin integrity such as soy bean meal, biotin and methionine (Berg 1998). Harms *et al* 1977 found that the incidence of footpad dermatitis in turkeys increased with biotin "deficient" diets. However, Mayne *et al* 2007 found that high dietary concentrations of biotin did not prevent foot pad dermatitis. These findings suggest other factors may be more important. Indeed, other research and experience has shown more simply that merely manipulating the moisture content of litter can induce significant foot pad lesions (Martland 1984, 1985). Investigations have shown that lesions can develop from as early as 3 days of age as reddening and developing inflammation of the foot pad (Clark *et al* 2002). The cause for these early lesions when generally litter conditions are dry is not clear. This may be related to localised dampness under drinkers or due to the sticky or abrasive nature of starter rations in which poult and chicks tend to tread. This is an area where more research is warranted.

Martland (1985) reproduced an ulcerative dermatitis in broiler chickens simply by spraying litter from 24 days of age with water twice weekly to produce wet crusty litter. Litter in the control pen was kept dry by regular top-ups with shavings. By 9 weeks of age, foot pad scores were dramatically increased in the wet litter groups and body weight was reduced. Moving birds from wet litter back to dry litter showed rapid recovery. Similar work has shown the same effect to occur in pen trials with 5 week old turkeys where litter was sprayed onto the litter every day such that by 9 weeks of age the incidence of pododermatitis was greatly increased (Martland 1984).

There is only limited information in the literature on the incidence of contact dermatitis under field conditions in Europe. Greene *et al* (1985) investigated field cases of contact dermatitis lesions in broiler flocks in Ireland. Examining lesions of the hock, breast and foot pads identified scabbing of the superficial epidermis through to severe ulcers filled with congealed exudates and litter. There was a subcutaneous inflammation that was predominantly very superficial. In such field cases, there was a slightly higher incidence in male birds and an increased incidence in winter months. Foot lesions were seen from 19 days of age and hock lesions from 22 days of age. The authors demonstrated a clear association with poor litter conditions.

A further study investigating contact dermatitis in commercial flocks in Ireland (Bruce *et al* 1990) surveyed 16 million broilers and demonstrated the prevalence of hock lesions at 21% and breast blisters at 0.2%. The breast lesions were strongly correlated to flocks with high incidence of hock lesions. Lesions were higher in male rather than female birds but no obvious direct effect of stocking density was demonstrated, although there did appear to be a direct relationship with increasing humidity. When investigating the economic impact of these lesions it was found that flocks which did not achieve their target income on performance had 5% higher level of hock lesions and eight times greater level of breast blisters.

Subsequently, Menzies *et al* (1998) reported a similar review of the performance results for 950 broiler flocks in Ireland involving some 15 million birds, for flocks reared between 1993 and 1994. Again, there was a higher incidence of contact dermatitis in males than females but in this work there was a more obviously increased prevalence at higher stocking densities. Overall, there was a decreasing incidence of hock burn in flocks achieving or improving on target net income. The overall incidence of hock burn between the two studies had reduced from 20.5% in 1986 (Bruce *et al* 1990) to 6.6% in 1994 (Menzies *et al* 1998), and it was considered that this was related to increased awareness of the influence of poor litter conditions and the introduction of control measures to maintain better litter condition.

Conclusion

Wet litter, moisture content and litter quality can have significant effects on bird health, performance and welfare. It can be difficult to maintain good litter quality under commercial conditions, but with good management, stockmanship, biosecurity and attention to detail bird health and welfare can be safeguarded. It is likely that welfare outcome indicators such as the incidence of footpad dermatitis and hock burn will be used increasingly to assess animal welfare under a variety of growing conditions, as a proxy measure of on farm litter conditions and levels of stockmanship and animal welfare.

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The causes of poor litter are many and varied. With such a multi-factorial causation, the solutions are likely to be equally complex. The goal is to assess the significance of risk factors on a farm by farm basis and to consider some of the following factors:

- Aim for optimal litter quality
- Aim for good intestinal integrity
- Maintain optimal environmental control
- Effective drinker management
- Use high quality feed rations and supplements
- Reduce feed changes and stresses
- Diagnose the role of infectious diseases
- Use antibiotics in a strategic way, when necessary
- Employ effective biosecurity at all stages to reduce disease challenges

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