FACTORS AFFECTING THE CONCENTRATIONS OF AIRBORNE BACTERIA AND ENDOTOXINS IN AUSTRALIAN PIGGERY BUILDINGS

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Introduction

The airspace of intensive piggery buildings is filled with a mixture of airborne bacteria, bacterial products and other pollutants such as particles and gases (Wathes *et al.* 1983). Different microorganisms are readily generated within animal buildings and after the death of gram-negative bacteria endotoxins are released. Previous publications revealed that significant amounts of airborne bacteria and endotoxin can be found in the airspace of piggery buildings (Seedorf *et al.* 1998). Piggery managers, scientists and building engineers are concerned with sub-optimal air quality, as high airborne bacteria and endotoxin concentrations could potentially affect the external environment, production efficiency, human and animal health/welfare. Different management, environmental and housing factors have been demonstrated in separate studies to influence the concentrations of different pollutants within piggery buildings (Attwood *et al.* 1987). However, these factors have not been evaluated simultaneously and very few studies have attempted to explain the variation observed in concentrations. Therefore, a comprehensive study of air quality in piggery buildings was designed to determine the key piggery design and management factors that affect the internal concentrations of respirable endotoxin and airborne bacteria in piggery buildings.

Material and Methods

The detailed methodology of the study was described by other papers in this series (Banhazi *et al.* 2004). The filters used to measure the concentration of respirable particles were analysed to establish the endotoxin concentrations in the dust samples using a commercially available Limulus Amoebocyte Lysate (LAL) test. Sampling of airborne bacteria was carried out using a standard Anderson sampler. The dependent variables (airborne bacteria and endotoxin concentrations) were log-transformed and analysed using a general linear model procedure (PROC GLM) (SAS 1989). The results from this analysis presented are based on Least Squares Means of fixed effects and best-fit slopes of covariates, where relevant.

Results

The results are shown in Figure 1 and 2.

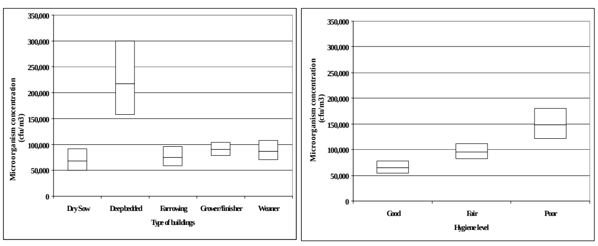

Figure 1: Effects of building type and floor hygiene on airborne bacteria concentrations (cfu/m^3) in Australian piggery buildings (LS means with 95% confidence intervals).

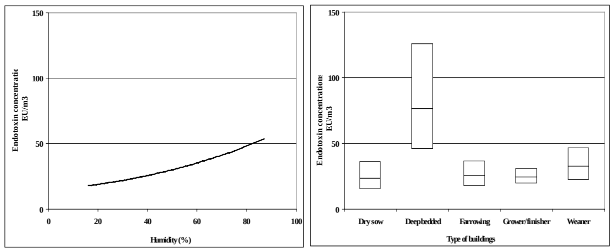

Figure 2: Effects of humidity and building type on endotoxin concentrations (EU/m3) in Australian piggery buildings (LS means with 95% confidence interval and estimated slope).

For airborne bacteria concentrations, the two main effects identified were building type and the level of hygiene (Figure 1.). For endotoxin concentrations, humidity levels and the type of buildings were shown to be significant (Figure 2.). The highest total airborne bacteria (2.17 x 10^5 cfu/m^3) and respirable endotoxin (76.26 EU/m^3) concentrations were detected in deep-bedded shelters (DBS).

Discussion

Several key factors affecting the both viable airborne bacteria and respirable endotoxin concentrations inside pig buildings were identified (Figure 1-2.). The type of building had a highly significant effect on both total bacteria and respirable endotoxin concentrations. DBS recorded the highest airborne bacteria and endotoxin concentrations (Figure 1-2.). The presence of bedding materials were clearly the main reasons for the high airborne bacteria and endotoxin concentrations measured in these buildings, as the effects of different bedding materials have been demonstrated in other species too (Banhazi *et al.* 2002c). Particles, containing endotoxins and airborne bacteria are readily generated in DBS under the dry Australian climate. Further studies on the relationship between the quality and management of bedding and endotoxin/airborne bacteria concentrations would be useful. Examining potential treatment and improved management of bedding materials could help to develop methods to reduce viable particle generation and endotoxin production in DBS. Improvement in air quality in DBS could potentially lead to additional production efficiency improvements in pigs housed in shelters, as well as reduced environmental impact of the operation and reduced health risks for both humans and animals.

The effect of pen floor hygiene (essentially pen cleanliness) on bacteria concentrations was a significant finding of the study. In previous studies (Aarnink *et al.* 1996), the concentrations of ammonia in piggery buildings were strongly associated with the extent of soiling of solid surfaces in pigpens. The current study however, demonstrated a direct link between hygiene level of pen floors and bacteria concentrations of air in livestock buildings. This association between pen hygiene and air quality arises as viable airborne particles and endotoxins are readily generated from dried faeces on pen floors. Faeces dried on the skins of the animals can also become a major dust/bacteria source. It is evident from the results that sub-optimal hygiene in traditional buildings is one of the main causes of high bacteria concentrations and therefore the improvement of pen hygiene can significantly contribute to healthier environmental conditions externally and in piggery buildings.

This study found that humidity affected endotoxin concentrations (Figure 2). Increased humidity in the air prolongs the survival time of different bacteria (Zucker *et al.* 2000). Generally, the natural half-life of airborne gram-negative bacteria ranges between a few minutes and perhaps an hour. After this time airborne bacteria die naturally and release increased amounts of endotoxins into the air. This finding has implications for dust reduction methods, such as spraying of oil/water mixtures. Spraying the floors of pig pens with a mixture of oil and water has been demonstrated by a number of authors to be an effective way of reducing dust (Takai *et al.* 1995; Banhazi *et al.* 2002b). However, this technique might generate higher endotoxin concentrations, due to the effects of humidity on endotoxins (Figure 2). This result might also explain the lack of positive effects of particle reduction on production efficiency from experiments using oil-spraying (Banhazi *et al.* 2002b). Additional experiments under controlled conditions would be required to understand these effects and possible interactions.

Based on the results of the study, improving pen hygiene is considered to be the most practical recommendation. This study demonstrated that dried faecal material deposited on pen floors is an important source of particles and airborne bacteria. Therefore, this source of airborne pollution should be reduced as much as possible by controlling dunging patterns and improving the hygienic conditions of pens (Banhazi *et al.* 2002a).

Treatment of bedding materials in DBS is also advisable to reduce the opportunities for particle generation (Banhazi *et al.* 2002c). However, care must be taken to ensure that during bedding material treatment the humidity levels are not increased as it might have an adverse affect on endotoxin concentrations. Therefore, further experiments are required to study humidity levels associated with treatments such as oil-spraying and determine the net benefit of such techniques.

The general control of humidity levels in piggery buildings would also be desirable. However, apart from reducing evaporative sources, such as leaking water lines and controlling dunging behaviour of pigs, there is little opportunity to practically control humidity levels in piggery buildings.

Conclusion

1. DBS showed the highest airborne bacteria and respirable endotoxin concentrations amongst all buildings types, 2.17 x 10^5 cfu/m3 and 76.26 EU/m3, respectively.
2. Bacteria concentrations were higher in pig buildings with poor pen hygiene.
3. Endotoxin concentrations increased with humidity levels.

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