FACTORS AFFECTING THE CONCENTRATIONS OF GASES IN AUSTRALIAN PIGGERY BUILDINGS

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Introduction

One of the important airborne pollutants present in livestock buildings is ammonia, and livestock production has been implicated in significantly contributing to atmospheric ammonia emissions (Arogo *et al.* 2003). High ammonia concentrations and emissions could potentially affect production efficiency, the environment and human and/or animal health. Carbon dioxide (CO_2) in piggery buildings is mainly produced by the animals and CO_2 is of great interest to livestock managers, as it is widely used to estimate ventilation rates of livestock buildings. A comprehensive study of air quality in piggery buildings was used to determine the key piggery design and management factors that affect the internal concentrations of these gases in piggery buildings.

Material and Methods

Numerous piggery buildings (160) were studied and information relating to the engineering and management factors influencing pollutant concentrations in the study buildings was collected. The concentration of ammonia and CO_2 was measured using the Multi-Gas Monitoring (MGM) machine. The collected data was log-transformed and analysed using a general linear model procedure (SAS 1989). The detailed methodology of the study was described by another paper in this series (Banhazi *et al.* 2004).

Results

The significant factors identified from the analyses are summarised in Table 1 and selected results from the GLM analysis are shown in Figures 1-2.

Table 1. Significant effects associated with ammonia and carbon dioxide concentrations (P<0.01).*

Ammonia ($R^2 = 0.214$)	**Carbon dioxide ($R^2 = 0.507$)**
Hygiene	Building type
Management x season	Season
Building size X season	Height of ventilation opening
	Ventilation control of ridge opening
	Ceiling height of shed x Ventilation control of wall openings
	Ridge vent height x Ventilation control of wall openings

*(*Effects involved in interactions were retained as main effects.)*

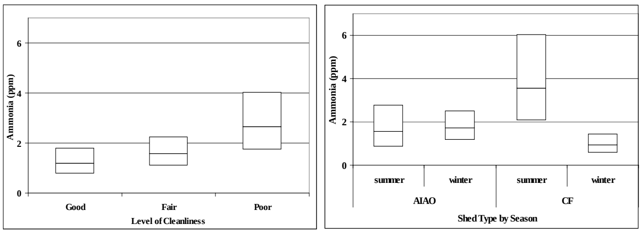

Figure 1: Effects of floor hygiene and pig flow management/seasons interaction on ammonia concentrations (ppm) in Australian piggery buildings (LS means with 95% confidence intervals).

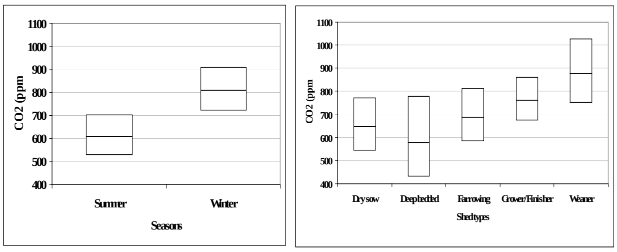

Figure 2: Effects of seasons and shed types on carbon dioxide concentrations (ppm) in Australian piggery buildings (LS means with 95% confidence interval).

The model developed for ammonia concentrations accounted for 21% of variation in the data. Ammonia concentrations were shown to increase as hygiene level decreased. Ammonia concentrations were higher in summer in continuous flow buildings (Figure 1). In terms of factors affecting carbon dioxide concentrations, seven main factors and two interactions were identified as being highly significant (Table 1).

Discussion

The important factors affecting both ammonia and carbon dioxide concentrations inside pig buildings were identified during the analysis (Table 1.). The effect of pig management by season interaction on ammonia (Figure 1) confirms the results of previous studies demonstrating the positive effects of all-in/all-out (AIAO) management on surface hygiene (Cargill *et al.* 1998). In AIAO buildings the effect of season is minimal, as the level of hygiene is probably also unchanged throughout the seasons and in winter no significant elevation in ammonia concentrations was observed in continuous flow (CF) buildings either. However, in summer time an increased ammonia concentration was detected in CF buildings. It is assumed that pen surface hygiene might be poorer in CF buildings compared to AIAO buildings and during summer more ammonia evaporates from the contaminated pen floors (Figure 1). Pigs also tend to soil pens more readily at higher temperatures (Aarnink *et al.* 2001). Therefore, summer appears to be a high-risk period for elevated ammonia concentrations in CF buildings. The significant effect of pen floor (surface) hygiene on ammonia concentrations (Figure 1) was an important finding of the study and confirms the results of previous studies (Aarnink *et al.* 1997; Ni *et al.* 1999).

The type of building had an effect on measured carbon dioxide concentrations (Figure 2). Deep-bedded shelters (DBS) recorded the lowest and weaner buildings the highest CO_2 concentrations. These results agree with expectation and relate to the general ventilation levels maintained in these types of buildings. Under Australian climatic conditions, weaner facilities are the most environmentally controlled buildings, while DBS are essentially open structures with close to maximum ventilation all year around. Dry sow facilities are loosely regulated environments in terms of thermal control, as it is generally believed that these large animals are able to deal with extreme temperatures (Lorschy *et al.* 1993). Therefore, ventilation levels in dry sow buildings tend to be generous and these buildings are ventilated as much as possible. Surprisingly, farrowing buildings had lower CO_2 levels measured than grower/finisher buildings, indicating that these buildings are less rigorously controlled than grower/finisher facilities. However, in Australia, the majority of pig producers tend to rely on localised heating and microclimate provision, rather than whole building thermal control to provide ideal environment for the newly born piglets (Houszka 2002).

As expected, CO_2 concentrations were higher in winter compared to summer (Figure 2). The increased ventilation rates used in summer in piggery buildings would result in reduced CO_2 concentrations in all buildings (Banhazi *et al.* 2001).

A negative relationship between the size of ventilation inlet (width or the distance between the lower and the higher end of air inlets) and carbon dioxide concentrations has been demonstrated. It is easy to see that as the air inlet size is increased the ventilation rate is also increasing and therefore the carbon dioxide concentration would decrease. Naturally ventilated buildings with larger air inlet are more intensely ventilated resulting in low carbon dioxide concentration rates. However, the overall quality of ventilation is influenced by other factors, such as air flow patterns, airflow control as well as by the quantity of air moved through the buildings.

Based on the results of the study, improving pen hygiene could be considered as the most important recommendation for ammonia reduction. The current practice of managing buildings using all-in/all-out strategy with thorough cleaning of the facilities between batches of pigs is advisable (Cargill *et al.* 1997). In terms of ventilation, Australian buildings are generally very well ventilated, as high ventilation rates are needed to control the thermal environment. However, the air quality improvement capacity of increased ventilation might be limited.

Conclusion

1. The ammonia concentrations were higher in pig buildings with poor surface hygiene.
2. Ammonia concentrations were the highest in summer in continuous flow piggery building.
3. Weaner sheds had the highest while deep-bedded buildings had the lowest carbon dioxide concentrations, indicating the level of ventilation.
4. Winter carbon dioxide concentrations were higher in all sheds compared to summer.
5. The size of air inlets negatively correlated with carbon dioxide concentrations.

Acknowledgements

This study funded by the Australian Pork Limited was part of a large collaborative project between the South Australian Research and Development Institute, Agriculture Western Australia, Agriculture Victoria and the Queensland based Swine Management Services. We wish to particularly acknowledge the contribution of pig producers involved in the study and Mr M. Militch of Cameron Instrumentation who assisted with the project instrumentation. We also would like to sincerely thank Dr C. Cargill, Dr B. W. Hall, Dr J. Black, Dr P. Glatz, Prof. C. Wathes and Prof. J. Hartung for their professional advice, and Dr S. Dreisen, Dr G. Marr and Mr H. Payne for their efforts of coordinating the data collection in different states. The important contributions of all technical officers (Mr R. Nichol, Ms S. Koch, Mr P. Daniels, Mr J. Weigel, Mr S. Szarvas and Ms A. Kefford) involved in the study are also gratefully acknowledged.

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