POTENTIAL OF EMITABLE AIRBORNE ENDOTOXIN CONCENTRATIONS IN AN AVIARY AND A CAGED HUSBANDRY SYSTEM FOR LAYING HENS

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Introduction

Gaseous and particulate pollutants in livestock buildings are potential health hazards for animals and humans. Due to this knowledge environment-related threats are also expected, because the ventilation system transports loads of pollutants into the surrounding air [1]. Especially for bioaerosols little is known about the environmental effects. To clarify such deficiencies a first step is the assessment of emission amounts for bioaerosols [2]. Poultry houses are generally causing the biggest particulate emissions, but different husbandry techniques can significantly influence the bioaerosol burdens. So far, husbandry systems for laying hens equipped with cages are increasingly criticised due to poor animal welfare. For that reason alternative animal keeping systems such as aviaries are promoted which fulfil requirements for adequate animal behaviour. Aviaries allow the birds to move freely, to scratch in litter and to fly. On the other hand sustainable livestock building designs have also to consider occupational and environmental aspects. Therefore, pro-inflammatory effective airborne endotoxins (as important part of bioaerosols) were simultaneously measured in a caged husbandry system and an aviary of an experimental laying hen house. The aim of the study was to show the dynamic of emission rates of endotoxins over a housing period of the two herds.

Material and Methods

Investigations were conducted in an experimental laying hen house with completely separated barns one equipped with conventional cages and one with structures typical for aviaries. Each barn was forced ventilated and housed 1,500 brown hens (Lohmann, Cuxhaven, Germany) with a mean body weight of approximately 1.75 kg. Within the compartments two sampling positions were installed in the longitudinal axis of the barn. For endotoxin analysis (LAL-Test) airborne inhalable and respirable dust were sampled at two and one position, respectively, with IOM samplers and cyclones (SKC Inc., USA). A central pump guaranteed the necessary flow rates. Ventilation rates were estimated with the aid of the carbon dioxide balance method using an infrared spectrometer for gas measurements. The 24 hour surveys were conducted 16 times over the housing period of the flocks and additionally accompanied by indoor and outdoor temperature measurements to get insight in seasonal variations, which possibly may cause none standardised monitoring conditions. Differences of husbandry-related data were statistically checked by the Mann-Whitney U-Test and associations between variables were calculated via Spearman rank correlation (r_S).

Results

The median indoor temperature did not differ significantly over the year (18.0 °C vs. 17.1 °C), although outdoor temperatures showed a clear seasonal trend. As expected from spring to summer increasing outdoor temperatures were observed (max. 19.5 °C), which declined down to a minimum value of 1.7 °C in winter time (Fig. 1).

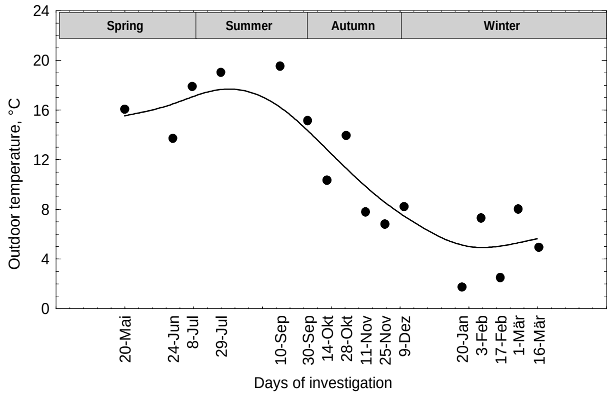

Fig. 1 Trend of seasonal depending outdoor temperatures during the investigation period from May (Mai) to March (Mär) in the following year. Dots represent the measured average temperature over 24 hours.

According to the ventilation needs during the seasons and the magnitude of endotoxin generation the emissions rates are quite variable as seen in Fig. 2.

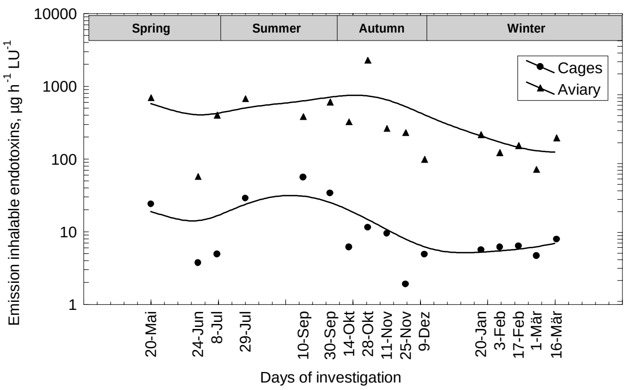

Fig. 2 Scatter plot of determined emission rates of inhalable endotoxins for hens in the caged system and in the aviary. Trend line indicate seasonal influences. LU =Livestock unit (500 kg body weight).

The emission pattern over the season is generally continued for the respirable endotoxin fraction as shown in Figure 3. However there is an exception during winter time. In the caged system a considerable and temporarily decline was observed in comparison to the aviary, which showed a constant decrease in the emission strength of respirable endotoxins. Therefore a significant correlation was just missed ($r_S = 0.39$; $p < 0.14$). A significant correlation could only be confirmed between cages and aviary in terms of inhalable endotoxin emissions ($r_S = 0.69$; $p < 0.003$).

Nevertheless, over the whole survey the median emission rates for inhalable endotoxins in the caged husbandry system and in the aviary were 6.3 µg h^{-1} LU^{-1} and 244.8 µg h^{-1} LU^{-1}, respectively. These values correspond to 0.7 µg h^{-1} LU^{-1} and 20.5 µg h^{-1} LU^{-1} in case of released respirable endotoxins. The differences were highly significant ($p < 0.001$).

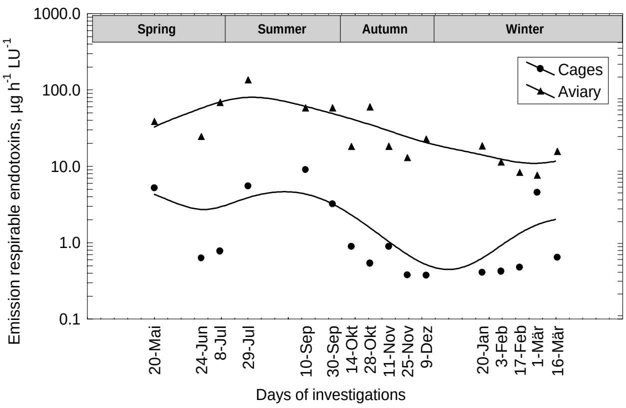

Fig. 3 Scatter plot of determined emission rates of respirable endotoxins for hens in the caged system and in the aviary. Trend line indicate seasonal influences. LU =Livestock unit (500 kg body weight).

Discussion

In the public the evaluation of husbandry systems is mainly dependent on animal health and animal welfare. But since the EU directive about the integrated pollution prevention and control has to be converted in national laws and regulations policy makers are forced to define so called best available techniques also in agriculture, which should cause a minimum pollution for the environment. In front of this background both the conventional husbandry systems have and the so-called alternative housing systems have to be evaluated. A comparison in respect to airborne endotoxins is given in this paper.

The emission potency of the caged system was significantly lower than the emissions from the aviary. The calculated mass flows for endotoxins was based on the multiplication of the ventilation rate and the airborne concentration of sampled endotoxins. Therefore, differences in emission quantities can be caused either by changes in air flow or by changes in endotoxin concentration. Indoor temperatures were rather equal in both barns indicating similar ventilation rates. As expected, no significant difference in the average ventilation rates was observed, but the determined inhalable and respirable endotoxin yields in the two investigated laying hen barns differed significantly ($p < 0.001$). In the aviary both endotoxin fractions were about 28 times higher in comparison to the conventional cages. A result which is confirmed in recent studies, where aviaries had also the highest endotoxin burdens (Seedorf et al. 1998). It is probable, that the availability of bedding material (scratching, sand bath) and a considerable higher animal's activity in the three-dimensional aviary (flying) has generated more airborne endotoxin containing dust. The results show that it is necessary to discuss the future development of animal friendly keeping systems for laying hens which are at the same time low in emissions. This is especially important in view of the occupational health of the workers in laying hen systems, because biohazards like endotoxins are causative agents for respiratory disorders.

Conclusion

In an experimental laying hen house an aviary and a battery cages system were compared in terms of their emission potency for inhalable and respirable endotoxins. The aviary showed a significant greater emission potency than the cage system. Potential confounders such as indoor temperature or ventilation rates could be ruled out as bias, because no significant differences between both husbandry systems were observed based on calculations over one housing period. Therefore, the differences of the emission loads were mainly caused by varying endotoxin concentrations within the barns. Feces loaded bedding material and the scratching and moving activities of the animals are main factors, which are causing considerable endotoxin releases dispersed in the environment.

Acknowledgements

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