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Research paper

Physical aspects of stabling systems in agriculture as a precondition of efficient utility

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Abstract

The need to create an appropriate welfare environment for animals, as a health and high yield factor, is increasingly coming to the fore. The environment has a continuous and direct impact on animals that quickly starts to show in their utility and health. In this respect, it is animals' immediate surroundings that play the most important role, i.e. the air in stables, also referred to as 'microclimate'. For example, the temperature of the air in stables has a direct effect on metabolic intensity and animal production, and an indirect impact on their health and welfare. It is therefore important to take into account thermal relationships between animals and the air in stables, as well as thermal relationships between a microclimate and the surrounding environment. The aim of this article is to assess the temperature and humidity characteristics of the indoor environment of two stabling units with different breeds of animals, taking into account performance indicators for milk production.

Keywords: *Agriculture engineering, Efficiency, Environment, Temperature, Humidity,*

1. Introduction

The environmental sustainability of animal agriculture has recently undergone considerable scrutiny as this issue comes to the fore of political, social, and economic agendas (Food and Agriculture Organization, 2010). Improving productivity demonstrably reduces the environmental impact of dairy production (Capper et al., 2009). This is achieved through the "dilution of maintenance" concept, whereby the maintenance nutrient requirement is spread over increased units of production, reducing natural resource use and greenhouse gas emissions per unit of milk.

The conditions for exploiting the genetic potential of livestock include appropriate nutrition, care and, last but not least, the housing environment in which the animals are reared (WEF, 2010; Garnett, 2013; Specht, 2015). The most important factor is animals' immediate surroundings, that is, the air in stables, also called microclimates (Bholah, 2002; Wahab, 2011). For example, the air temperature in stables has a direct effect on metabolic intensity and animal production, and an indirect impact on animals' health and welfare (Veissier, 2008; Langford, 2012). It is therefore important to take into account thermal relationships between animals and the air in stables, as well as thermal relationships between a microclimate and the surrounding environment. Unsuitable stable conditions and inappropriate microclimates can cause temperature stress in animals, directly leading to production losses and worsened animal welfare (Burge, 2004). Insufficient ventilation increases the risk of animal disease, and health can be directly damaged by high atmospheric concentrations of dangerous gases (Lindenmayer, 2011; De Vries, 2011).

The quality of a microclimate is influenced in particular by physical, chemical and biological factors (Levinson, 2010; Mueller, 2012). The main determinant of physical factors is temperature and humidity (the so-called temperature-humidity complex), air flow, cooling air, solar conditions, lighting, barometric pressure and noise levels (Kuosmanen, 2005; Taylor et al., 2000). Chemical elements include chemical composition of air, specifically with regard to concentrations of toxic gases as ammonia, carbon dioxide and hydrogen sulphide. Biological factors mainly map the concentration of dust particles and microorganisms dispersed in the air (Hansen, 2008).

Air temperature is the most important factor, because its changes must immediately react to the animal's organism, which in extreme cases can affect the utility or even the health of the animals (Crowe, 2012; Dikmen et al., 2008; Hillmann, 2004)). It follows that the surrounding thermal factors of the stables environment are an important factor in terms of the impact on the animal organism. Animals which have a constant body temperature developed a complex physiological function called thermoregulation, through which the body maintains a constant body temperature. It follows that the surrounding thermal factors of the stables environment are an important factor in terms of the impact on the animal organism (Romaniuk et al., 2005). Similarly, the humidity of the indoor stables environment is as

important as the air temperature in the housing areas (Handler, 2011). Air humidity is given by the content of water vapour that is always in the air but in varying amounts.
Based on these factors understood as a precondition of efficient livestock productivity, we specified the objective of our analyses. In the initial analysis, we focused on assessing the temperature and humidity characteristics of the indoor environment of two different stabling units with two different breeding animals, taking into account performance indicators for milk production.

2. Material and methods

Animal production facilities are designed to provide optimal conditions for the rearing of healthy and high-yield animals. Construction structures and material compositions must be designed to resist a specific setting environment throughout their lifetime or operation resistant to a specific stable environment (Martins, 2015; Katunsky, 2015; Lesniak and Zima, 2015; Spengler, 2000; Woloszyn, 2008). In our work, we focused mainly on the basic physical factors of the indoor environment of the stables areas, which are temperature and humidity.
The subject of the research was two types of breeds intended for milk production. These spaces were comparable in terms of occupancy as well as volume capacity. The difference was in the breed of the animals. The Holstein and Jersey breeds were compared in terms of the effect of the air temperature in these spaces on the indicators of milk yield.
As for the thermo-technical parameters, the buildings considered were energy-comparable, so it was assumed that the stable areas would create an environment with mild and continuous temperature changes without extreme fluctuations due to external weather factors.
The testo 635 instrument was used to measure and monitor the temperature and humidity of the analysed areas. The testo 635 temperature and moisture meter allows you to carry out temperature and moisture measurements on a variety of different materials, surfaces and environments.
Holsteins are known for their outstanding milk production, desirable phenotypic characteristics, and adaptability to a wide range of environments. The breed was developed in the Netherlands. Holsteins are unsurpassed in terms of milk production and are inexpensive to keep considering what they are capable of producing for their owners (Falta et al., 2018; Gantner, 2011).
Jersey probably originated from the adjacent coast of France, where in Normandy and Brittany cattle resembling Jerseys are found. Jerseys are well known for their milk which is noted for its high quality and is particularly rich in protein, minerals and trace elements. It is also rich in colour which is naturally produced from carotene, an extract from grasses. The Jerseys hava an ability to adapt to many kinds of climates, environments and management practices (Javed, 2002).

3. Results and discussions

Based on longer term climate monitoring in terms of temperature characteristics, we have come to the conclusion that each species and age of livestock requires different temperature and humidity ratios to be provided as we want to achieve optimal environmental conditions for achieving the highest productivity. However, the statistical analysis did not reveal a statistically significant difference between the compared animal species (p=0.4078). For livestock, especially as regards dairy cows, it is desirable to prevent rapid day-to-day fluctuations and to maintain a constant air temperature with admissible multi-day daily fluctuations. If those requirements were not respected in the winter, it would necessarily be less productive at higher feed consumption.

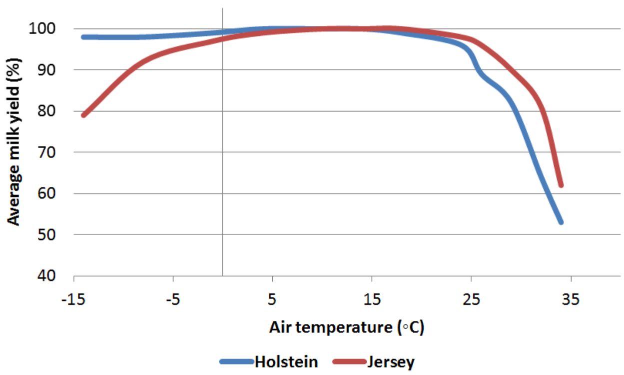

Fig. 1: Dependence of the production capacity of dairy cows on the air temperature in stable

As can be seen from the values in Fig. 1, even more unfavourable results are obtained for the production performance of dairy cows when the interiors are excessively overheated due to insolation in the summer months. Trough a statistical analysis at the significance level of P <0.05, a statistically significant impact of the air temperature on the average Holstein breed yield was observed for Holstein (p=-0.6890). In the case of the Jersey breed, an impact of temperature on milk was also observed, but this dependence was not statistically significant (p=-0.2605).
Maintaining a constant air temperature in an area to ensure maximum production efficiency is also justified by the basic characteristics of homoiothermic animals' organisms.

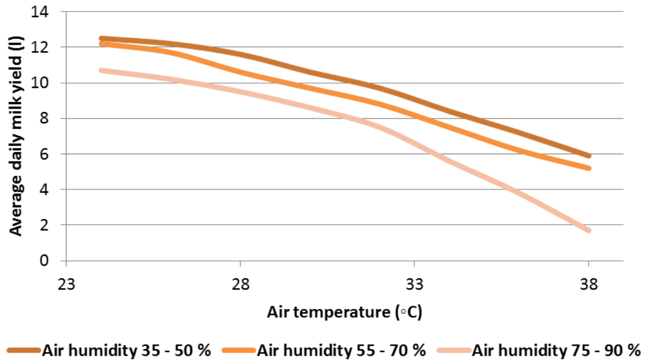

Fig. 2: Dependence of milk production on air humidity in stable.

The optimal relative air humidity range is one in which air humidity does not adversely affect animal health and performance. Even with this parameter, the daily average value is decisive. On the basis of the observations, we observed an impact of relative air humidity on the average daily milk production shown in Fig. 2. The statistical analysis confirmed the significant difference between the observed moisture intervals and the average daily milk production ($P<0.0001$) of the analysed dairy cows.

4. Conclusion

Based on the analysis of the collected data, we found a difference between the compared breeds of dairy cows, taking into account the basic physical characteristics of the inner characteristics of the stables. Our findings show that the optimal temperature range is one where livestock is the most productive, with the lowest cost of feed and the smallest losses, while maintaining optimum humidity and air flow rates.

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