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Spatial microclimate patterns in reconstructed and new large uninsulated loose housing cowsheds

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Abstract

Keeping heifers and dairy cows in uninsulated loose housing cowsheds is spreading in the cold regions of the world. During the last decade, cold cowsheds have spread into all the Scandinavian and Baltic countries. In 2002, two large cowsheds were studied: a cowshed renovated from an old collective farm cowshed to a cold building (RUC) and a newly finished one-nave steel-framed loose housing cowshed (UC). The measurements of air temperature, relative humidity, air velocity and lighting were taken indoors and outdoors.

The movement of air in the cowshed was visualized with smoke using bellows. Investigations were carried out in summer and in winter considering average Estonian climate conditions. In summer, when all ventilation openings and doors (as well) were opened, the air temperature in the cowsheds was homogeneous and similar (variance 1.7–2.5 °C). In winter the air temperature variance was 4.4 °C higher in RUC, but the values remained within the range of cows' temperature comfort zone. Relative humidity was acceptable for cows in both cowsheds in summer (69–83.3%) and winter (60–90.8%) conditions. In quiet days (wind velocity up to 2.4 m/s) the air velocity values in the cowsheds were mostly acceptable for cows in summer (0.05–0.86 m/s) and in winter (0–0.35 m/s). The lighting was better and more uniform in UC while in RUC there were places with low lighting values even on sunny days.

Keywords: Loose housing; Dairy cows; Uninsulated; Cowshed; Microclimate

1. Introduction

Keeping heifers and dairy cows in uninsulated loose housing cowsheds is spreading in the cold regions of the world. It has been determined that keeping cattle in cold cowsheds is possible and useful even when outdoor temperatures fall as low as −34 °C [1]. Comparative studies made in Northern Utah proved the benefits of cold cowsheds over warm (insulated) ones, in respect to both economics and health of the cattle [2]. During the last decade, cold cowsheds have spread into all the Scandinavian and Baltic countries [3–5]. During the past few years in Estonia, several large (up to 600 animals) uninsulated free housing cowsheds and cowshed complexes (up to 1000 animals) have been completed. Since the application of cold cowsheds requires answers to several questions in the fields of microclimate, construction, economics, technology and the health of animals, studies in the field are characteristically interdisciplinary.

Questions related to the design and construction of cold cowsheds have been discussed [6]. It has been noted that the construction of a new cold cowshed and the reconstruction of an older insulated cowshed into a cold cowshed are both cheaper than constructing a new insulated building [7]. From the research of Riina Miljan it transpired that, although in the short perspective it is economically more efficient to reconstruct old cowsheds, when economic support and other benefits are included in investment projects, it becomes more efficient in the long run to build new cowsheds [8].

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A very important welfare factor is air distribution within the cowshed. According to ASAE EP270.5, the primary definition of a ventilation system is a system for providing a desired amount of fresh air, without drafts, to all parts of the shelter [9].

Ventilation could be estimated by the rate of air exchange, which is easy for insulated cowsheds with chimneys and mechanically ventilated cowsheds, where the air speed in chimneys or fan speed is measured [10]. For uninsulated buildings with large openings the ventilation rate could be estimated by indirect methods: balance of animal heat, carbon dioxide, measurement of pressure gradients [10]. Also, a good method to evaluate ventilation is to study air distribution, which is a more qualitative factor than the rate of air exchange. The air distribution can be estimated by comparing the air temperature, relative humidity and velocity in different areas [9].

Studies of the cold cowsheds' microclimate have been carried out since the winter of 1994 [11–14].

In 2002, when two large cowsheds—a cowshed renovated from an old collective farm cowshed to a cold building and a newly finished one-nave steel-framed loose housing cowshed, were put into operation, it became necessary to

1. determine the spatial microclimate patterns in the reconstructed (RUC) and new uninsulated (UC) cowsheds in winter and summer conditions,
2. investigate the natural ventilation through the eaves and ridge openings with different settings of the blinds covering them,
3. compare and evaluate the suitability of the microclimate for dairy cows in the reconstructed and new cowsheds.

2. Materials and methods

Estonian air temperature data [15] are given in Fig. 1.

The average air temperature variability in Estonia is from −6.7 to 16.4 °C. However, absolute temperature variability is from −42.6 to 34.0 °C. In the current study, summer and winter microclimate patterns at average temperatures are discussed.

RUC: Standard project TP801-254 (96.6 × 22.6 m) for 292 cows using tied housing was one of the most commonly used types of cattle sheds for large farms during the Soviet occupation in Estonia. The cowshed is made of concrete elements. Bearing structures (poles and beams) are made of reinforced concrete. Walls are made of gas concrete panels and blocks, and ceilings of reinforced concrete panels. The cowshed used to have four rows of cows with two manure and three feeding alleys. The distance between bearing structures is 9 + 4 + 9 m across the building and 6 m along the

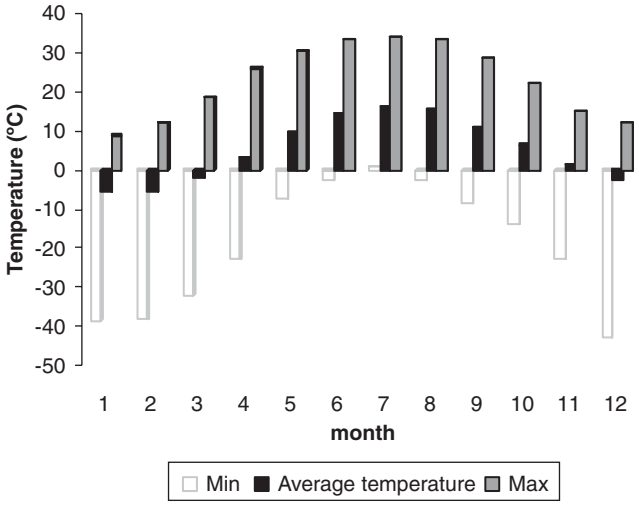

Fig. 1. Air temperature data in Estonia.

building, which is of great importance in planning a building layout (Fig. 2). There are a large number of these structures standing empty today.

Reconstruction design is planned as follows: ventilation is designed to be natural (Fig. 3). Glass windows are replaced with a plastic net, which has to reduce wind speed, but has no calculable thermal resistance (*R*-value). Fresh air enters through these wall openings. Also, adjustable plastic blinds were to be installed. Air flows out through the continuous ventilation channels in the ceiling and roof. As the boundaries like walls and ceiling are not changed, it is not correct to name it "uninsulated". The name "cold" suits this cowshed better.

UC: The measurements of the 300 place loose housing cowshed with steel frames as bearing structures are 29.6 × 88 m (Fig. 2). The lower 1.5 m reinforced concrete part (height 1.5 m) of the 3.0 m exterior non-load-bearing wall is supported on concrete foundation blocks (Fig. 3). The roofing is made of corrugated non-asbestos fiber–cement sheets. Five rows of translucent sheets provide light for the cowshed. The floor is made of reinforced concrete. Thanks to the use of steel frames, one large 30 m span is created. This allows comparatively easy rearrangement of technology. Ventilation is performed through the eaves, wall openings and an opening in the roof ridge. The wall openings (height 1.2 m) can be closed by blinds. When the blinds on the walls are closed, they still leave an eaves opening of at least 15 cm between the roof and the top of the wall.

Visualization of air flow patterns is an important step before any measurement of any microclimate parameter. It can be done by measuring air velocity or by mixing smoke and air [14].

The placement of the measuring points in reconstructed and new uninsulated cowsheds can be seen in