SPATIAL MICROCLIMATE VARIABILITY IN LARGE UNINSULATED COWSHED

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Introduction

Estonia is located near the Northern border of profitable agricultural production. Average temperature variability is from -6.7 to 16.4ºC; absolute temperature variability from -42.6 to 34.0ºC. Keeping young animals and dairy cows in uninsulated loose housing cowsheds is spreading in the cold regions of the world. In the year 2000 there were over 50 cold cowsheds for dairy cows in use in Estonia (Veermäe et al., 2001). During the past few years several large (up to 500 animals) uninsulated cowsheds have been completed. As it is economically more efficient to large-scale produce and to introduce complete solutions, microclimate studies of the cowshed are required by the builders, cattle-breeders, veterinarians and animal protection specialists.

Materials and methods

The studies were carried out in a 300 place loose housing cowshed in Torma. The schematic layout of the cowshed and the locations of measuring instruments can be viewed in figure 1. Measurements were taken as follows: 29th August 2002 (version I – blinds open), 7th November 2002 (version II – left side blinds closed ¾, right side closed ¼), 6th December 2002 (version III – blinds on both sides closed, roof ridge open) and 6th January 2003 (version IV – blinds and roof ridge opening closed, eaves openings covered with plastic strips, snow on the roof) at points A1… E6 (1 m above floor level) and outside (1 m above ground level) following measurements were taken: temperature (Testo 615), relative air humidity (Testo 615), air movement speed (Testo 425), ammonia (Portable gas-meter PAC III Dräger), lighting (TES 1332). The movement of air in the cowshed was visualized with smoke using bellows.

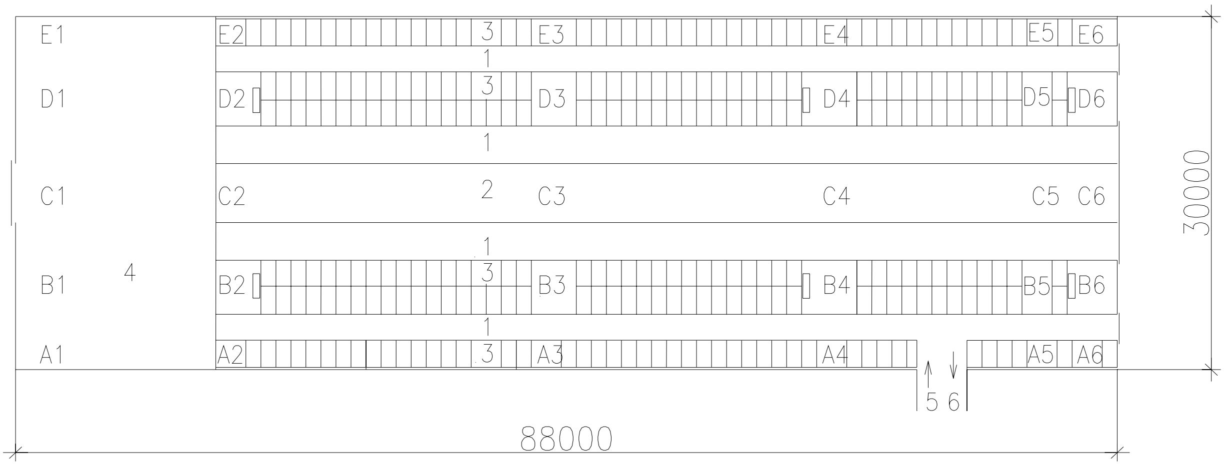

Figure 1. The layout of cowshed. 1 – walking area, 2 - feeding alley, 3 – cubicles, 4 - feed storage and service area, 5 – entrance to milking parlour, 6 – exit from milking parlour, A1…E6 - the measurement points

Results and discussion

When all the openings were uncovered, the air moved along the cowshed following the direction of the wind. Wall-openings functioned as both inlets and outlets of air. Across the cowshed the air movement was from bottom to top.

When wall-openings were closed, eaves- and roof ridge openings open and wind blew alongside the building, the air movement scheme was ‘classic’. The air entered through the eaves-openings, dropped soon lower and after mixing with the warmer air rose higher again, towards the roof ridge. The movement of air along the length of the building was also noticeable, following the direction of the wind outside.

In case of especially cold weather, the roof ridge openings were also closed in addition to the wall-openings. In such cases the air movement scheme inside the cowshed became complicated. Along one side of the cowshed the air moved following the direction of the wind outside. On the other side, where the connecting corridor and milking parlour were situated, the movement of air was in opposite direction. Across the building whirls were formed. Eaves-openings functioned as inlets and/or outlets of air. Such scheme cannot be considered desirable for air ventilation. The temperature measurement results can be viewed in table 1.

As the openings were gradually closed, the difference between the temperatures outside and inside the cowshed grew. When the outside temperature was –23.0°C and all the openings were closed, the air temperature inside the cowshed fluctuated by 6.7°C. The average indoor temperature -9.2°C differed from the outside temperature by 13.8°C. The air humidity measurement results can be viewed in table 2.

Table 1. Temperature data in cowshed

Item	Version	Date	Outdoor	In cowshed				
				Average	Max		St-dev	
Temperature, ºC	I	29.08.02	26.4	26.2	27.0	25.5	0.4	1.5
	II	07.11.02	1.1	2.6	3.7	1.5	0.6	2.2
	III	06.12.02	-9.6	-6.2	-4.4	-7.6	0.6	3.2
	IV	06.01.03	-23.0	-9.2	-5.3	-12.0	1.8	6.7

Table 2. Relative humidity data in cowshed

Item	Version	Date	Outdoor	In cowshed				
				Average	Max		St-dev	
Relative humidity, %	I	29.08.02	34.4	42.1	47.4	38.6	1.9	8.8
	II	07.11.02	69.3	73.7	77.2	69.9	1.8	7.3
	III	06.12.02	79.4	82.2	90.8	76.7	3.6	14.1
	IV	06.01.03	70.1	75.7	91.8	52.0	9.8	39.8

With the closing of openings when all the fans were shut and the outdoor temperature was at –23.0°C, the fluctuations of relative air humidity inside the cowshed increased, reaching 39.8% (53.0...91.8%) (version IV).

Table 3. Air movement speed in cowshed

Item	Version	Date	Outdoor	In cowshed				
				Average	Max		St-dev	
Air movement speed, m/s	I	29.08.02	0.6	0.2	0.7	0.0	0.1	0.7
	II	07.11.02	0.8	0.2	0.5	0.1	0.1	0.5
	III	06.12.02	0.2	0.1	0.4	0.0	0.1	0.3
	IV	06.01.03	0.3	0.0	0.1	0.0	0.0	0.1

Table 4. Lighting in cowshed

Item	Version	Date	Outdoor	In cowshed				
				Average	Max		St-dev	
Lighting, lux	I	29.08.02	29133	2099	4757	293	1247	4463
	II	07.11.02	2570	138	328	14	88	314
	III	06.12.02	5500	163	391	16	118	375
	IV	06.01.03	6980	21	128	8	21	121

When the openings were closed, relative air humidity did not go up as the temperature fell. Estonian Engineering Design Standards do not deal with microclimate of cattle-breeding structures. Swedish indicators are recommending 60.0…80.0% relative air humidity for insulated cowsheds and in case of cold cowsheds the indoor air humidity should not exceed the one outside by more than 10% (Dolby, 1989). The results from measurements can be viewed in table 3.

The outside wind-speed was low during the test-periods (0.2... 0.8 m/s). With the closing of openings the fluctuations in the air movement speeds and the average air movement speed grew smaller. There were no areas with draught. The results from measurements can be viewed in table 4.

The lighting inside the cowshed fluctuated greatly. During the last measurements, the roof of the cowshed was under a thick layer of snow, causing the lighting to be below optimal (120 lux). Under such conditions it would be expedient to use additional lighting also at daytime.

The suitability of the gaseous composition of the air was calculated by the amount of ammonia detected. At all measurement points the ammonia content was below the detectable range of the measurement instruments (1 ppm). The maximum advisable ammonia content in the air is 10 ppm.

Conclusion

It is possible to conclude, basing on the measurements taken, that such loose housing uninsulated cowsheds have suitable microclimate for dairy cows in Estonian climate conditions. However, in some locations indoor relative humidity tends to be too high. Also, when the roof of the cowshed was under a thick layer of snow, the lighting was below optimal (120 lux). Under such conditions it would be expedient to use additional lighting also at daytime.

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