Original scientific paper: DOI 10.7251/JAS1502031E UDK 636.2.084.429:637.12.04

EFFECT OF CERTAIN BARN CONSTRUCTION CHARACTERISTICS ON INDOOR CLIMATE STATUS IN DAIRY BARNS IN BOSNIA AND HEREGOVINA

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ABSTRACT

The aim of this field study was to describe climatic status in dairy barns in lowland and in mountainous regions of BiH, and to examine correlations between chosen housing parameters and indoor climate. Totally 76 herds were visited once by a team of trained observers in 18 municipalities in Bosnia and Herzegovina. All barns in mountain region had tie-stall housing system (MH), while 30 barns in lowland regions had tie-stall system (LTS) and 8 of those loose housing (LLH) with or without cubicles. Presence of CO2 was quite different between groups, the average lowest was found in LLH and it was 627.5 ppm (ranging from 390 – 890), in LTS 936.7 (390-1690), in MH 1105.7 (390-5390). The highest measures roof temperatures were at LTS, and the average was 12.7, while in LLH were 10.49, MH 11.14 and AF 11.70. Mean floor area per animal for all farms was 6 m2/animal, in MH 6.4, LTS 5.4 and LLH 6 m2/animal. Mean barn volume for all farms was 27.9 m3/animal, in MH 25.5, LTS 26.5 and LLH 44.2 m3/animal. Average barn height was 3.6 m for AF, 5.7 m for LLH, 4 m for LTS and 2.8 meters for MH. The negative correlations between construction environment parameters was found for all combinations except for the air velocity in LTS barns. Some of the construction parameters could help in overall estimation of the housing quality in dairy cattle barns.

Key words: dairy cattle, construction of the barn, carbon dioxide, ammonia, air velocity

INTRODUCTION

Housing potentially provides protection from aversive climatic conditions (Legrand et al., 2009), but depending on housing quality it may also exacerbate extremes (Phillips, et al., 2013). Housing conditions and management are important factors affecting the health of dairy cows and other aspects of their welfare. Housing, including thermal conditions, has multifactorial consequences that can affect cow welfare and health. The relationship between the animal and its environment determines the degree to which an animal remains in thermal equilibrium with its environment

(Finch, 1976). Poor building design and unsuitable microclimate may result in thermal stress or diseases, resulting in decreased productivity and risks to their welfare (Charles, 1981; Cena and Clark, 1981). Poor ventilation may also increase the relative air humidity or concentrations of gases like carbon dioxide and ammonia. Humidity in animal houses originates from direct evaporation from the animals, their breathing or by evaporation from urine and faces (Charles, 1981; Cena and Clark, 1981). Even low concentrations of ammonia are considered to endanger health (Danuser et al., 1988; Brautbar et al., 2003). BiH dairy sector is still based mostly on small scale farms. Loza (2014) found that as much as 75.8% of the commercial dairy herds in BiH are smaller than 5 cows, and majority of the farms have tie-stall housing system.

Hence, the aim of this field study was to describe climatic status in dairy barns in lowland and in mountainous regions of BiH, and to examine correlations between chosen housing parameters and indoor climate.

MATERIALS AND METHODS

The research was carried out in the period from December 5th, 2013 to March 15th, 2014 and 76 herds were visited once by a team of trained observers in 18 municipalities in Bosnia and Herzegovina. Farms were randomly selected from the database of Register of agricultural Producers (www.apif.net), from which half of the herds (n=38) were selected from a geographical area lower than 300 meter above sea level (lowland herds) and the other half of the herds (n=38) were selected from a geographical area above 600 meter above sea level (mountain herds). All barns in mountain region had tie-stall housing system (MH), while 30 barns in lowland regions had tie-stall system (LTS) and 8 of those loose housing with or without cubicles (LLH). Mean herd size of all farms (AF) were 11.9 dairy cows (range 5-107), in MH was 11.9 dairy cows (range 5 to 74), LTS barns accommodated 16.2 dairy cows in average (range 6-54) and LLH herds had 51.4 dairy cows (range 21-107). A systematic protocol was used to record data on each farm. This protocol was an adapted version of that one used in the Norwegian KUBYGG-project (Simensen et al, 2010). The dimensions of visited objects were measured by laser distance meter (LDM50, PCE instruments, UK). Based on these numbers, area per animal (not accessible space) and total air volume per animal was calculated. Farm height was always measured at the highest point of the barn from inside. Temperature and air humidity was measured using Thermo anemometer PCE-423 (PCE Instruments, UK), and from those parameters was calculated THI. Air velocity was also measured by PCE-423. Carbon dioxide (CO_2) and ammonia (NH_3) were measured in the center of each building using IBRID MX6 (Industrial Scientific Corporation, USA). Roof temperature was measured by Infrared laser thermometer PCE-777 (PCE Instruments, UK).

For the statistical analyses, herd was the statistical unit. Based on the recorded data from multiple animals per herd, herd means was first calculated and then used in the analyses. Then were done correlations of the between selected indoor climate parameters (and housing parameters of the barn.

RESULTS AND DISCUSSION

The THI was lowest in MH and was 48.6, then LLH 50.2, LTS 53.6 and at AF 50.94, and those values were not extreme, as EFSA (2009) suggested that cows are subject of discomfort when THI exceeds 75. There were not detected some higher concentration of NH_3, and on those were from 0 – 3 ppm. Presence of CO_2 was quite different between groups, the average lowest was found in LLH and it was

627.5 ppm (ranging from 390 – 890), in LTS 936.7 (390-1690), in MH 1105.7 (390-5390) and at AF was 988.68. The highest presence of CO_2 was detected in MH farms, and was 5390 ppm. EFSA (2009) suggested that cows are adversely affected by gas concentrations in dairy cow houses exceeding: ammonia 10 ppm, H2S a measurable amount e.g. 0.5 ppm, carbon dioxide 3000 ppm. The highest measures roof temperatures were at LTS, and the average was 12.7, while in LLH were 10.49, MH 11.14 and AF 11.70. Mean floor area per animal for all farms was 6 m^2/animal, in MH 6.4, LTS 5.4 and LLH 6 m^2/animal. Mean barn volume for all farms was 27.9 m^3/animal, in MH 25.5, LTS 26.5 and LLH 44.2 m^3/animal. Average barn height was 3.6 m for AF, 5.7 m for LLH, 4 m for LTS and 2.8 meters for MH.

Correlations

In next tables there are shown correlations between selected construction parameters of barns height (in further text: height), area per head in m^2 (A/H) and volume per head in m^3 (V/H), on one side and temperature humidity index (THI), air velocity, NH_3, CO_2 and roof temperature (roof T), on the other side.

All farms

Tab. 1. Correlation between chosen parameters at AF

N=76	*THI*	*Air velocity*	*NH3 ppm*	*CO2 ppm*	*Roof T*
HEIGHT	-0,0406 p=0,728	0,1822 p=0,115	0,1111 p=0,339	-0,1869 p=0,106	-0,2446 p=0,033
A/H	-0,1511 p=0,193	0,0819 p=0,482	-0,0423 p=0,717	-0,0091 p=0,938	-0,3335 p=0,003
V/H	-0,1424 p=0,220	0,1100 p=0,344	0,0030 p=0,979	-0,1022 p=0,380	-0,3337 p=0,003

When all groups were joined and analyzed as one group (AF), the height was negatively correlated with THI and CO_2 (table 1). Correlations of barn height for AF stalls and examined microclimate parameters are of negligible for THI to very weak for air velocity, CO_2 and NH_3. The highest correlation coefficient was recorded between building height and the temperature of the roof, with the emphasis that the correlation is negative, which is logical. The height of building, the space allowance also contributes to air quality and thus welfare by its association with air volume (EFSA, 2009). Correlations between A/H and microclimate parameters are of negligible to weak. A negative correlation was observed between (A/H, THI, NH3 and CO2), except when the air velocity. The highest negative correlation was observed between the A/H and the roof T. V/H was negatively correlated to THI and CO2 Roof T, and positive correlation was observed at air velocity and NH3. As in the previous two cases, the highest negative correlation was observed between V/H and the roof T.

Loose housing lowland

The height of the barns LLH showed a negative correlation for THI, air velocity, NH3 and roof T (Tab. 2). A strong negative correlation was found for THI, indicating that the size of the object directly influences the temperature comfort dairy cows. A strong negative correlation was found for air velocity parameter. This could be explained by the building's structure. In these barns height was usually higher than in other groups, windows are usually placed at higher altitudes (under the roof) and air velocity measurements were done at the level of heads of animals. Correlation coefficients between the A/H and microclimatic parameters THI, NH_3 and roof T were in negative relations (Tab. 2). Positive correlations were between A/H and air velocity and CO_2. Correlation with CO_2 is negligible, and to the air velocity is weak. Comparing air velocity correlations between construction parameters for AF and LLH, we can notice higher correlations in loose housing farms, what could be effect of higher available area per head and more space for air circulations.

Tab. 2. Correlation between chosen parameters at LLH

N=8	*THI*	*Air velocity*	*NH3 ppm*	*CO2 ppm*	*Roof T*
HEIGHT	-0,7120 p=0,048	-0,8274 p=0,011	-0,2866 p=0,491	0,0753 p=0,859	-0,1041 p=0,806
A/H	-0,0391 p=0,927	0,2717 p=0,515	-0,0389 p=0,927	0,0821 p=0,847	-0,2970 p=0,475
V/H	-0,4458 p=0,268	-0,3181 p=0,443	-0,1200 p=0,777	0,1542 p=0,715	-0,2136 p=0,611

Negative correlations were found between V/H and air velocity, NH3 and roof T. For NH_3 and roof T correlations were negative and very weak, for the air velocity was low, and the T and THI medium negative. The very weak positive correlation between A/H and CO_2, could be result of higher percent of decomposition of organic matter (straw) in those barns, as straw lies longer at the barns, comparing to tie-stalls in both regions bellow 300 m.a.s.l. and above 600 m.a.s.l., and also there is more straw used in those types of barns (Tab. 5).

Tie-stalls lowland

The negative correlations between construction environment parameters was found for all combinations except for the air velocity in LTS barns (Tab. 3). The largest negative correlations were observed between the parameters of construction facilities and the concentration of CO_2 and roof T. When it comes to the negative correlations between CO_2 and design characteristics of the studied objects/stables, it provides information that higher space per head, reduces the concentration of CO_2, as well as the roof T.

Tab. 3, Correlation between chosen parameters at LTS

N=30	*THI*	*Air velocity*	*NH3 ppm*	*CO2 ppm*	*Roof T*
HEIGHT	-0,0253 p=0,894	0,2048 p=0,278	-0,0015 p=0,994	-0,1531 p=0,419	-0,2657 p=0,156
A/H	-0,1720 p=0,364	0,0131 p=0,945	-0,1857 p=0,326	-0,4526 p=0,012	-0,3449 p=0,062
V/H	-0,1735 p=0,359	0,1682 p=0,374	-0,1329 p=0,484	-0,3831 p=0,037	-0,3955 p=0,031

Pedersen, S. and Sällvik, K. (2002) suggested that lower calculated ventilation increased measured CO_2. Results from this research showed also that spacious animal room could help in dispersion of CO_2. Air velocity has positive but very weak correlation with barn construction parameters and seems all are related to barn indoor environment (Tab. 3).

Mountain farms

Correlations between constructional parameters of MH (Tab. 4) showed negative correlations with THI. The highest negative correlations were observed ($p < 0.05$) for the roof T, which indicates the close connection between the total available space for animals and a roof T. The air velocity shows in relation to the construction solutions very weak positive correlation, and suggest that the flow increases with the increase of usable space in the barn. The correlations between CO_2 and certain characteristics of the objects were negligible.

Tab.4, Correlation between chosen parameters at MH

N=38	*THI*	*Air velocity*	*NH3 ppm*	*CO2 ppm*	*Roof T*
HEIGHT	-0,2050 p=0,217	0,1721 p=0,301	0,1240 p=0,458	-0,0849 p=0,612	-0,4416 p=0,006
A/H	-0,1068 p=0,523	0,1362 p=0,415	0,0943 p=0,573	0,0474 p=0,778	-0,3228 p=0,048
V/H	-0,1082 p=0,518	0,1285 p=0,442	0,0899 p=0,592	-0,0408 p=0,808	-0,3526 p=0,030

CONCLUSIONS

Conducted research showed that there are differences between housing systems and building approach among three groups of barns/farms, low land group housing barns, lowland tie-barns and mountain barns. Some of the construction parameters could help in overall estimation of the housing quality in dairy cattle barns.

ACKNOWLEDGEMENTS

The authors thank the participating farmers as well as the people at APIF for their helpfullness during the study. The study was financially supported by the Norwegian HERD programme.

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